

WAHL

Applications of
Compressed Air
for Motive Power

Mechanical Engineering

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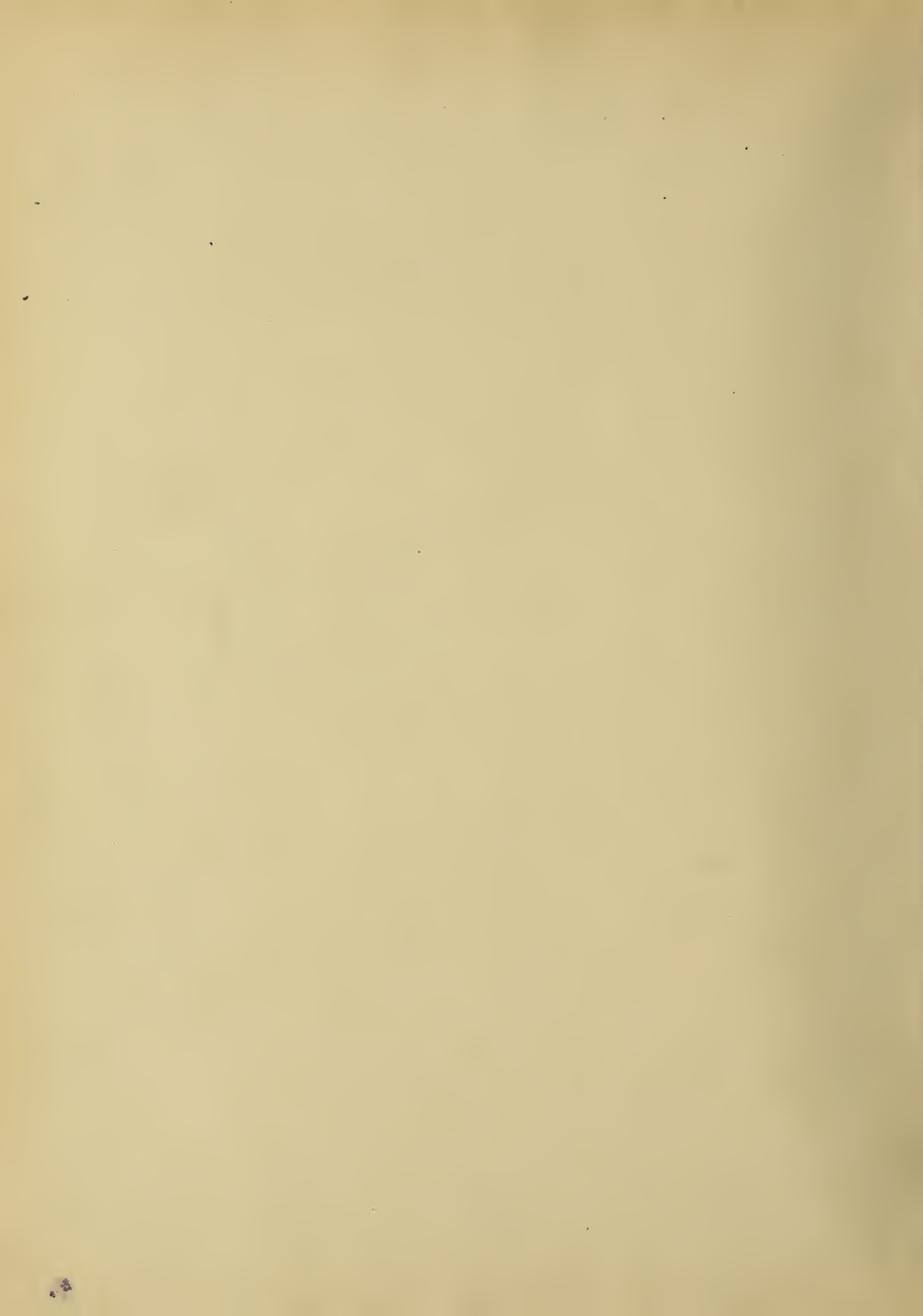
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Applications of Compressed Air for Motive Power

.. BY ..

HENRY WAHL

THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN
MECHANICAL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

OF THE

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1901



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May 31, 1901 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Henry Wahl

ENTITLED Compressed Air

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering.

L. P. Breckinridge

HEAD OF DEPARTMENT OF Mechanical Engineering.

Historical Review of the Uses of Compressed Air.

The first authentic patent for compressed air machinery was taken out in England in 1726 by Rowe. From that time up to the beginning of the nineteenth century there were many attempts to pump water by means of slightly compressed air.

In 1799 Medhurst took out a British patent to compress air for motive power by means of a wind-mill, and in 1828 Bompos in a provisional British patent proposed to propel locomotives by compressed air. In the same year Colladon proposed to employ compressed air in the Thames tunnel.

However, the first decided advance in the science of compressed air and its applications was made by William Mann. In his patent he states that by application of compressed air, power and motion can be communicated to fixed machinery, carriages, locomotives and ships. In the description of his method of compressing air, he says: " The condensing pumps used in compressing the air I make of different capacities, according to the density of the fluid to be compressed, those used to compress the higher densities being proportionally smaller than those previously used to compress it at the first or lower densities. It is evident from this extract that Mann discovered the advantage of compound compression.

In 1836 James Surrey in a British patent suggests portable vessels filled with compressed air for the use of railways; he also suggests a central compression plant with a system of piping between stations.

In 1844 Arthur Parsey patented a regulating device between the

receiver and cylinder.

In 1847 Von Rathen in an English patent describes the processes of wet cooling and jacket cooling; he also describes a refrigerator for cooling the air after compression and also a reheater.

In 1852 Colladon applied for an Italian patent for the use of compressed air as a power for driving the rock drills in tunnel construction.

January 15th. 1854 Arthur Parsey patented in England the double acting air pump with hollow piston rod, through which air is admitted. The valve may be as large as the cylinder. The rod passes through the valve and has a spiral spring to keep the valve seated.

The above summary is intended to point out in a slight degree the most important steps in the development of the compressed air machinery of the present day.

Compressed Air as a Motive Power for Vehicles or Trucks.

The "Compressed Air" for March 1900 gives illustrations and descriptions of compressed air propelled vehicles showing their development in the line of the auto-truck. The New York Auto-Truck Co. has been carrying on a line of experiments to demonstrate the feasibility of compressed air vehicles for street haulage.

The first carriage of this type was built in 1895 and 1896 to establish the general principles, the milage, regulation and control by this power. The power was applied by a Hoadley-Knight motor. It was found that on one charge it would run 14 miles and ascend a grade of 20 per cent at 8 miles an hour. Air was reheated by a small coal fire.

The second vehicle was a factory truck for handling heavy weights around the factory yard at Worchester, Mass.; it was capable of carrying 10 tons. This vehicle had no provision for preheating, as it was not required to run long distances, and it could be recharged at any moment.

With this development to demonstrate the power and feasibility of compressed air a tractor was built, which was a sort of compressed air locomotive. The power was controlled by the feet and the steering was done by the hands. Controlling treadles extended out from the standard in front of the drivers seat, convenient as a foot rest.

By pushing one foot down the vehicle was caused to go forward, and by pushing the other foot down it was caused to go backwards, while putting both feet down in a medium position brought the vehicle

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to a standstill. This tractor is said to have developed a hundred horse-power and to have hauled 40 tons on railroad cars. Hot water under 600 pounds steam pressure was used for reheating.

The tractor may be seen hauling railroad cars and also pulling coal wagons on the streets of Worchester, Mass. Other tractors were built on similar lines, and were used in Providence, R.I. at the works of the International Power Co., for factory work. In connection with a low gear truck, the forward wheels of the gear being dispensed with and its forward end being hung by a link under the rear axle of the tractor, thus making a "Lorry" of the tractor. This was followed by the auto-truck which was adapted to carry a load on its back and represents the most powerful automobile which has yet been produced. It is capable of carrying a load of 10 tons up a grade of 10 per cent.

The view shown was taken in Providence, R.I. The truck was used for factory work, hauling large castings. It was afterwards taken to New York and used there for hauling lumber. The weight of the loads shown was 18000 lbs. This truck is the prototype of other trucks now being built by the International Power Co., and they differ in points, weights and material. The weight of the new truck is much less and the material of a character designed for permanency.

"Compressed Air" of January 1900 contains a cut and description of an air driven wagon.

The engine used in the air wagon is of the usual two cylinder type and weighs 36 lbs. and has several special features in its construction. It is adapted for the use of steam or air, as required. With the use of air it has a storage capacity of six cu. ft. which

could be increased without material addition to the total weight of the wagon, which is with the present capacity 670 lbs.

With air as a power, appliance for reheating the air is used. The air is stored at a pressure of 2500 pounds per. square inch and reduced to an initial pressure of 150 pounds by an arrangement of reducing valves, which are under the control of the operator, and allows the working pressure to be regulated as required.

On a recent trial on bad road this wagon was operated with a consumption of 60 cubic feet of free air per. mile. The conditions of the road was much below the average, and the trial was not one which would give the most economical results in the use of the power, yet under these conditions, the storage has capacity to run the carriage twenty or thirty miles.

"Compressed Air" of December 1898 contains the following in regard to a compressed air truck.

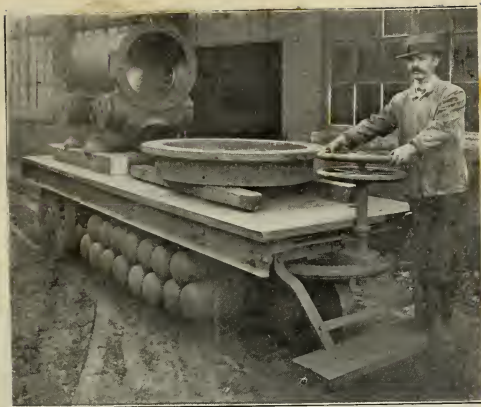
The truck shown in cut is of one in daily use at the works of the American Wheelock Engine Co., Worcester, Mass., and is used for moving large castings and other bulky work from place to place.

This truck will handle ten tons and occupies a space of four by fifteen feet. It is claimed that it will run about half a day on one charge of air and will operate with a power cost not exceeding one cent a mile. The motor used is of the Hoadley-Knight type, that is to say, it is an iron-clad motor having all its working parts in a closed iron basin partly filled with oil so that no attention for lubrication is required.

A simple wedge movement enables its operator to reverse the motor or control the point of cut-off. This is done by the lower hand wheel shown in the cut. The upper wheel is for steering purposes, it being connected to a segmented gear, attached to a single steering wheel. The throttle is controlled by a lever which is opened by the operator pressing his knee against it and is closed by a spring. The motor drives both the rear wheels through a compensating bevel gear arrangement thus allowing it to turn in any direction. The truck when working under ordinary conditions, consumes about 75 cubic feet of air per. mile. This involves a cost of less than one cent per mile for power.







COMPRESSED AIR TRUCK.



THIS AUTOMOBILE IS OPERATED BY COMPRESSED AIR, AND BUILT BY
THE AMERICAN VEHICLE CO., NEW YORK.



A TYPICAL MOTOR TRUCK. MOTIVE POWER, COMPRESSED AIR.

Compressed Air as a Motive Power for Locomotives.

The Railway Journal of June 1899, Vol. 2 page 14, contains the following about compressed air locomotives in practical operation at the mines of the Philadelphia and Reading Coal and Iron Co., Ashland Coal and Iron Co., and the Jefferson Coal Co., also at the works of the Plymouth Cordage Co. The users of these locomotives report that they are doing excellent service.

It is claimed that these engines for the service intended are more reliable and more economical in installation and operation than other systems.

They are absolutely safe from fire and handier in operation than a steam engine of the same size. The leading anthracite and bituminous colliers have adapted them after exhaustive examination. We are therefor forced to accept the claims made in their favor.

The compound system shown in the P. and R. C. and I. Co. engine number 44 is found to be more economical in the use of air as it gives a greater range of expansion in the cylinders than the ordinary single expansion system. This engine was the first one of its type put into service and has handled 45 empty coal cars weighing 2300 pounds each on a grade of 1.6 per. cent.

These air engine tanks usually carry a working pressure of 600 pounds per. square inch.

Specifications of some of these engines are given below:-

Four-coupled mining pneumatic locomotive for the Ashland Coal and Iron Co.-----Cylinders 14x9 with plain valve; air tanks, one 26.5 inches in diameter and 18 feet 5 inches long; one 26.5 inches in

The first period of the earth's history is the period of the formation of the earth's crust. This period is divided into three main periods: the period of the formation of the earth's crust, the period of the formation of the earth's atmosphere, and the period of the formation of the earth's hydrosphere. The period of the formation of the earth's crust is the longest and most important period of the earth's history. It is the period during which the earth's crust was formed and the earth's atmosphere and hydrosphere were created. The period of the formation of the earth's atmosphere is the period during which the earth's atmosphere was formed and the earth's hydrosphere was created. The period of the formation of the earth's hydrosphere is the period during which the earth's hydrosphere was formed and the earth's atmosphere was created.

It is believed that the earth's crust was formed by the action of the earth's internal heat. The earth's atmosphere was formed by the action of the earth's internal heat and the earth's hydrosphere was formed by the action of the earth's internal heat and the earth's atmosphere.

The earth's crust is the solid part of the earth. It is the part of the earth that is visible to the eye. The earth's atmosphere is the gas part of the earth. It is the part of the earth that is invisible to the eye. The earth's hydrosphere is the liquid part of the earth. It is the part of the earth that is invisible to the eye.

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diameter and 15 feet 9 inches long; one 15.75 inches in diameter and 13 feet 5.75 inches long, thickness of sheet $1\frac{1}{2}$ inch and $\frac{3}{8}$ inch, thickness of head $\frac{5}{8}$ inch, working pressure 100 pounds, storage pressure 600 pounds.

Driving wheels, outside diameter 28 inches, diameter of center 24 inches, journals 4x6 inches; wheel base, drivers 5 feet 3 inches, weight on drivers 20500 pounds, gauge 3 feet 7.5 inches.

Compound four-coupled mining pneumatic locomotive for the Philadelphia and Reading Coal and Iron Co.-----Cylinders, diameter, high pressure 5 inches, low pressure 8 inches, stroke 12 inches, balanced piston valve. Air tanks; one 32 inches in diameter 16 feet long, one 32 inches in diameter 13 feet 6 inches long, one 14.5 inches in diameter 13 feet 4 inches long. Thickness of sheets $\frac{3}{8}$ inches, thickness of head $\frac{9}{16}$ inches, working pressure 200 pounds, storage pressure 600 pounds.

Limit of height of engine 5 feet 3 inches, limit of width 6 feet, limit of length 16 feet.

Driving wheels, outside diameter 24 inches, diameter at center 20 inches, journals 4x6 inches, wheel base driving and total 4 feet 6 inches, weight on drivers and total 22000 pounds, gauge 3 feet 8 in.

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. The McCormick Harvesting Co. of Chicago have six compressed air locomotives to take the place of about sixteen drays in doing their draying. The compressed air power being the safest as there was so much inflammable material and danger from fire. No tests have been made as to the amount of air required to run those locomotives but it is said that they will work continuously for about two hours on one charge using air at twenty-five hundred pounds pressure.

The following photographs of the Porter locomotives were furnished with the compliments of the manufacturers.

1. The following is a list of the names of the persons who have been appointed to the various committees of the Board of Directors of the American Telephone and Telegraph Company, for the year ending December 31, 1911.

The Board of Directors of the American Telephone and Telegraph Company, for the year ending December 31, 1911, has appointed the following committees:

The Finance Committee, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The General Management Committee, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Engineering Committee, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Legal Committee, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Public Relations Committee, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Committee on the Relations of the Company to the Government, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Committee on the Relations of the Company to the Public, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

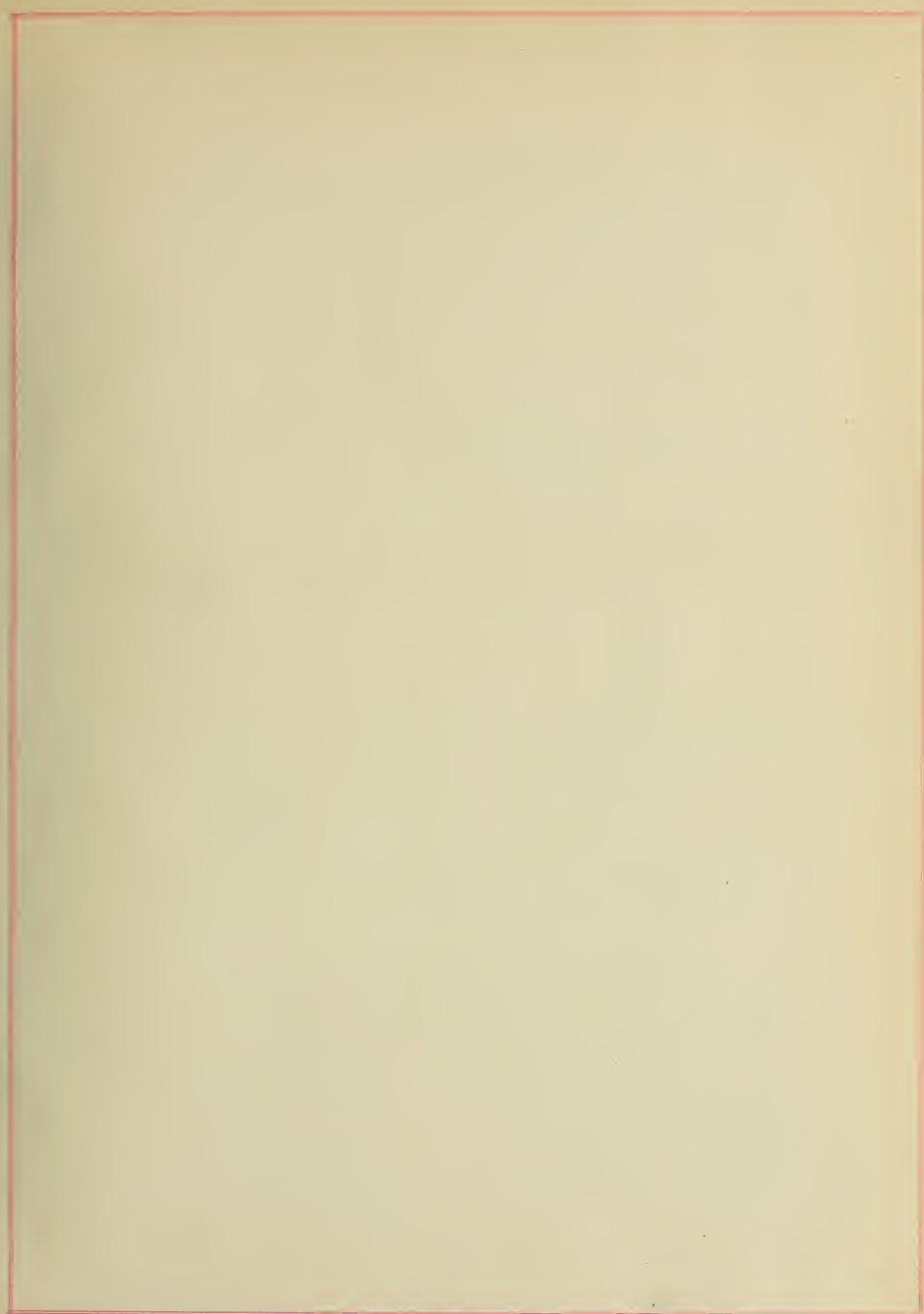
The Committee on the Relations of the Company to the Stockholders, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

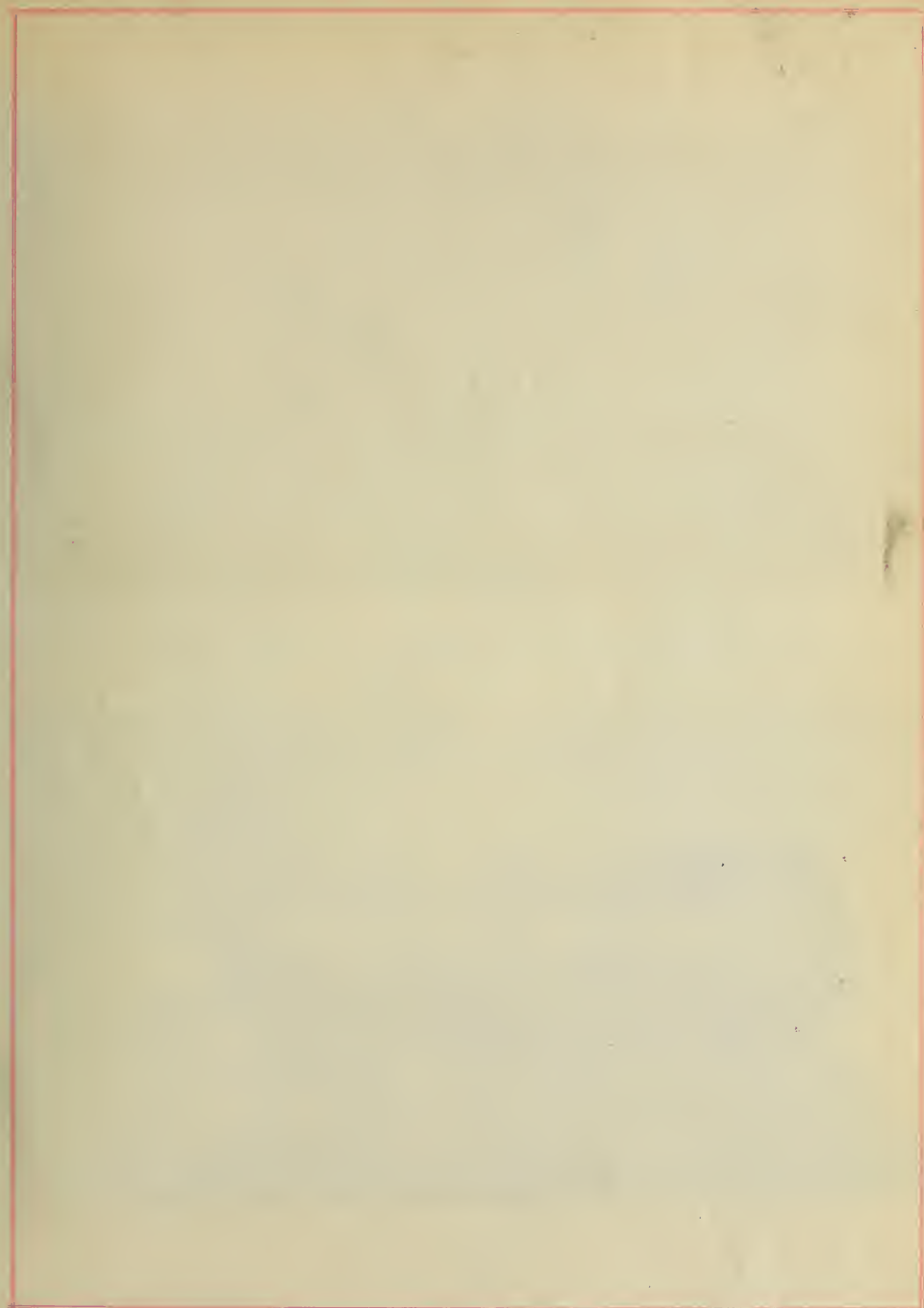
The Committee on the Relations of the Company to the Creditors, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Committee on the Relations of the Company to the Employees, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Committee on the Relations of the Company to the Community, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.

The Committee on the Relations of the Company to the World, consisting of Messrs. J. P. Morgan, Jr., Chairman, and Messrs. C. D. Smith, Jr., and J. D. Rockefeller, Jr.







1871

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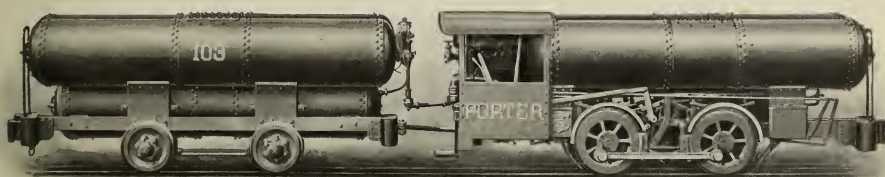
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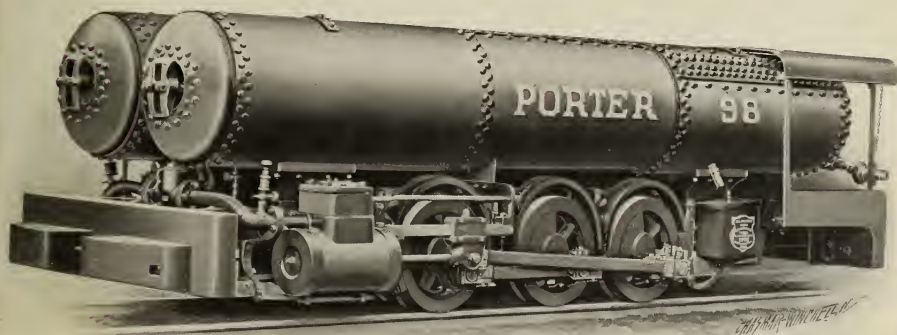
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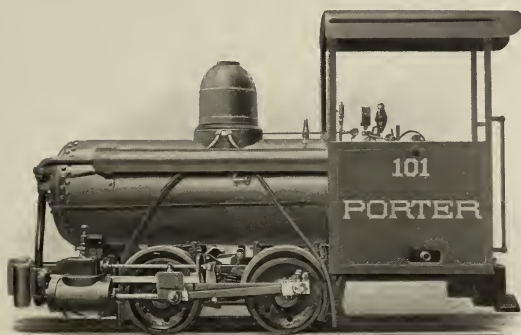
Compressed Air Mine Locomotive, Four Driving Wheels, with Four-Wheel Air Tender



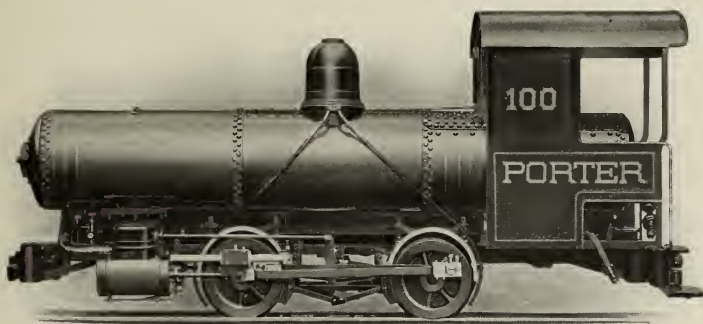
Compressed Air Mine Locomotive, Two Tanks, Six Driving Wheels



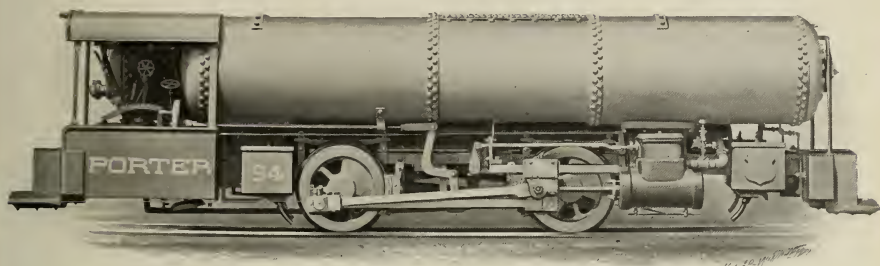
Compressed Air Industrial Locomotive, Single Tank, Four Driving Wheels



Compressed Air Industrial Locomotive, Two Tanks, Four Driving Wheels



Compressed Air Mine Locomotive, Two Tanks, Four Driving Wheels



Compressed Air Mine Locomotive, Single Tank, Four Driving Wheels



Compressed Air as a Motive Power for Street Railways.

"The American Machinist" for May 6th. 1898 describes the Hardie system of compressed air locomotives for the Manhattan Elevated R.R. of New York.

The air at a pressure of 2000 pounds to the square inch is carried in 36 Mannesman tubes, each nine inches in diameter and fifteen feet six inches long. The total cubical contents is 246 cubic feet, which at above pressure is equivalent to 33702 cu. ft. of free air. The weight of the full charge of dry air will be over 2500 pounds.

The tubes are all so connected, the connections being in the forward end and easily accessible, as to form one continuous reservoir. The air first passes from the reservoir to a pressure-reducing valve which maintains a constant working pressure of 150 pounds, which pressure, within certain limits, may be varied under the control of the engineer.

The air, after its expansion to this working pressure, passes through a vertical tank of hot water in the cab. This water is heated by steam, at each recharging of the air reservoirs, to about 350 degrees F. The air passes actually through the hot water and is thereby not only heated and expanded but takes up a volume of steam about equal to one half its own volume, the actual practical results of the expansion of the air and mixture of steam with it being to double the work done by the air.

From the heater the air goes as directly as possible to the engine cylinders. These are 13.5 inches in diameter and 20 inches stroke, being placed under the cab instead of in the usual place forward.

"The Journal of the Royal Society of Medicine," for the year 1900, has been published. The volume contains the proceedings of the Society, and the transactions of the various committees and sub-committees.

The air of a room, at 1000 yards, is the same as the air of a room, at 1000 yards, and the same as the air of a room, at 1000 yards. The air of a room, at 1000 yards, is the same as the air of a room, at 1000 yards. The air of a room, at 1000 yards, is the same as the air of a room, at 1000 yards.

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This arrangement is done to secure as short a run as possible from the heater to the cylinder.

As the cylinders on the steam locomotives on this line are only 12 inches diameter, the air locomotive will have more power, will start the trains quicker from the stations, and will be able to make better time.

Cassiers Magazine for June 96 contains the following on "Compressed Air for Street Railways", by Whitfield Price Pressinger.

Up to this time an impartial and fair demonstration had not been made of the use of compressed air in street car service. In this employment it can present no arbitrary claims for its adoption but must compete on an equal footing with established methods, the basis for this comparison being cost of installation and operation. When the inventor who undertakes to design and construct a compressed air street motor, is able to convince street railroad capitalists by an actual demonstration that his system can be installed and successfully operated at a reduced cost per. car run, then, and then only will compressed air be used in service. The history of the various compressed air motors which have been exploited from time to time is a checkered one, but the fact that compressed air yet lacks a thorough demonstration, is due either to incompetent efforts or to causes entirely foreign ^{to} and beyond the control of those interested.

The first to be tried, in America at least, was the Hardie motor, which was constructed at the Baldwin Locomotive Works at Philadel-

phia and tested in New York city about 1881.

Subsequently the Judson system, taking its power from a continuous compressed air conduit the entire length of the line, was tested and abandoned. Then the Atmospheric Propulsion Co. built an experiment car and progressed no farther. The rights of the Mekarski system, extensively used in France, are controlled in the United States and cars have been run here, but it has not flourished as in the land of its conception.

All these motors, with the exception of the Judson, were designed upon the storage system being provided with cylindrical receivers carried under the car body. These receivers were charged at a central station with compressed air to a high pressure and the air was supplied to the motor cylinder on the car, at the requisite working pressure, by means of pressure reducing valves. Provision was made for restoring the radiated heat energy to the air before it was used and air brakes were employed.

On down grades no air was consumed and in fact, the motor cylinders could be utilised as compressing pumps, to restore air under pressure to the receiver whenever the car was propelled by gravity. The entire mechanism was controlled by the motorman from his place on the front platform and required no higher grade of ability than in managing a cable or trolley car.

In this employment of compressed air power as in others, Continental Europe and particularly France, made the earliest demonstration of any magnitude. In the suburbs of Paris and at Nantes compressed air tramways have been in operation for several years.

Consequently, the present study, being the first of its kind, is a contribution to the knowledge of the life cycle of the organism. The study is a preliminary one, and it is hoped that it will lead to further research. The study is a preliminary one, and it is hoped that it will lead to further research. The study is a preliminary one, and it is hoped that it will lead to further research.

All these studies, with the exception of the studies, have been made by the same person, and it is hoped that they will lead to further research. The study is a preliminary one, and it is hoped that it will lead to further research. The study is a preliminary one, and it is hoped that it will lead to further research. The study is a preliminary one, and it is hoped that it will lead to further research.

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A report relative to the tramway near Paris states that the many advantages of this system have been fully established by over two years experience and claims the following. The motor does not emit smoke or hot gases and is almost noiseless. Any desired rate of speed can be attained and may be varied at will to suit conditions. A special track or overhead appliance is unnecessary. Being very light it can be easily handled on steep grades. Simple in form it does not frighten horses; the machinery on the front platform is almost invisible from the outside. One person only is required to manage the machinery and he need not necessarily be a skilled engineer.

The principle of the system is very simple; the storage reservoirs of the car are charged with compressed air at the supply station to a pressure of 45 pounds and reduced and used at 5 to 10 pounds, being at the same time heated to a high temperature and charged with moisture in a heating vessel.

Another method tried in Paris was the Popp-Conti system. The details of their invention vary from the other prominent methods in that a low air pressure is employed, the car reservoirs being recharged automatically at intervals along the line.

The Journal of the Franklin Institute for July, August and September of 1899 contains the following in regard to pneumatic transportation and cuts of cars operated under different systems. The systems are, the Hughes and Lancaster System, the Jarvis System and the Mekarski System at Toledo Ohio.

The cost of operating air cars based on seven months operation

begining August 3rd. 1896. The length of track is 10854 feet or 4.11 miles on which two air cars were substituted for cable cars each making nineteen round trips or 79.09 miles per car. The total daily distance traversed being 157.32 miles. Each car runs from 12.5 to 16.67 miles on a single charge of air.

Actual average cost per car mile for entire period, seven months, 125.16 miles per. day.

Coal-----	\$.0563
Water-----	.0103
Oil and Waste-----	.0013
Power Plant Labor-----	.1261
Conductor and Motorman-----	.0608
Repairs, Car Equipment-----	<u>.0038</u>
Total-----	\$.2586

Average present cost per car mile with one car service performed 78.09 miles per. day.

Coal-----	\$.0675
Water-----	.0113
Oil and Waste-----	.0017
Power Plant Labor-----	.0833
Conductor and Motorman-----	.0698
Repairs, Car Equipments-----	<u>.0038</u>
Total-----	\$.2284

Average present cost per car mile with two car service 156.18 miles per. day.

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Coal-----	\$.0483
Water-----	.0103
Oil and Waste-----	.0013
Power Plant Labor-----	.0833
Conductor and Motorman-----	.0608
Repairs, Car Equipment-----	<u>.0028</u>
Total-----	\$.2018

If the proportion of labor actually utilised in this service is considered, the expense would only amount to \$.1791 per. car mile at present.

Present number of employes six beside motorman and conductor.

The cost of operating the same line, 4.11 miles, with electric cars was \$.2991 having however only five employes.

The average consumption of free air per. car mile for the seven months service was 477.7 cubic feet.

In a severe snow storm the cars performed schedule time carrying twenty per cent. more passengers and using twenty-two per cent more power than the day previous. Comparing results with an electric road with thirty-three per. cent less service than the day previous the load on the power plant was eighty per cent greater.

The air storage reservoirs on these cars have a capacity of 51 cubic feet sufficient to run the car 18 to 20 miles continuously.

The reservoirs consist of seamless steel flasks capable of standing a pressure of double that used without reaching the elastic limit of the metal and ^{there is} no possibility of leakage. Between the flasks and the motor is placed a small tank containing 6 cubic feet

1. The first part of the report is a general survey of the situation in the country. It deals with the political, economic, and social conditions, and with the progress of the various branches of industry and commerce. It also mentions the state of the public mind, and the influence of the press and the pulpit.

2. The second part of the report is a detailed account of the various branches of industry and commerce. It describes the state of agriculture, the progress of the manufacturing and mining industries, and the condition of the commerce and navigation. It also mentions the state of the public mind, and the influence of the press and the pulpit.

of water which is heated by passing steam through it while the air flasks are being charged. This tank is lagged with non-conducting material so as to prevent loss of heat. Numerous experiments have proved that the cars will run nearly twice the distance with air heated in this way as with cold air.

The air is exhausted so low as to cause no sound in exhausting.

The motor mechanism consists of two simple link-motion reciprocating engines having cylinders 7 inches in diameter and 14 inch stroke with valve cutting off at $1/10$ to $1/6$ and applying power by connecting and parallel rods direct to the crank pin of the drive wheel, which are 4 in number, 26 inches in diameter, running on a wheel base of 7.5 feet. Upon this four wheeled truck rests the entire weight of the car and mechanism evenly distributed upon elliptical springs.

The mechanical features of the motor are substantially the same as steam locomotive minus boiler and fire-box and needs no comment.

The car is simple in manipulation, perfectly noiseless, odorless, and free from all offensive features which place it at the top for a public conveyance.

In the report of the Metropolitan Street Railway Co. New York, for the year ending June 30th. 1900 the comparison of the relative cost of operating cable, electric and horse railroads is given. It is there stated that the total operating expenses for 9812031 horse-car miles averaged 18.98 cents per. car-mile; that 10610091 cable-car miles averaged 17.76 cents per. car-mile and that

24968196 electric-car miles averaged 13.16 cents per. car-mile. These figures were made to include all expenses as nearly as possible. The compressed air cars on the 28th. and 29th. street lines in New York have been running about two months, and in that time have run considerably less than 100000 miles. The maximum number of cars being twenty.

Careful estimate, made to conform as closely as possible to the scope of the report previously quoted, establishes 17.42 cents per. car-mile for the compressed air operation to date.

When it is considered that these twenty cars are being operated from a central plant, which has a capacity for probably 100 cars of the same individual power as that now used, the further estimate made by the Compressed Air Co. showing that this cost can probably be reduced to 13.57 cents is not unreasonable.

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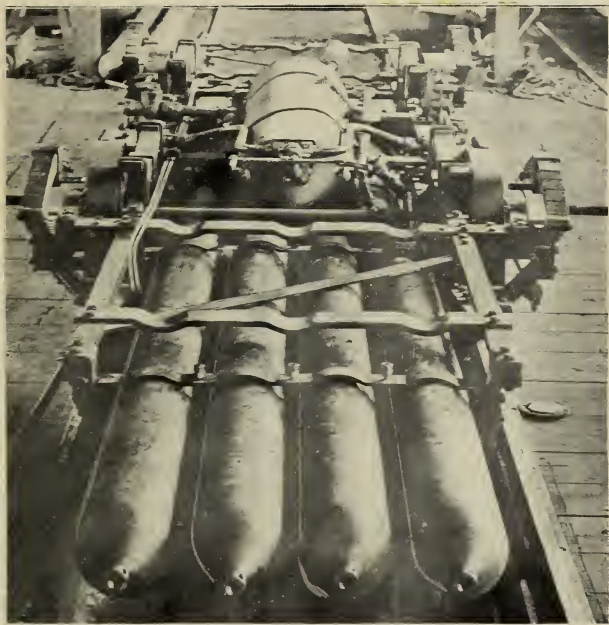


THE NEW HARDIE AIR-MOTOR.

Recently introduced on 28th and 29th Street line, New York City, by the Metropolitan Street Railway Company.



The above cut is of a 28 foot Compressed Air Motor Car hauling two trail cars in Chicago.



VIEW OF TRUCK OF THE NEW HARDIE AIR MOTOR CAR BODY REMOVED. THE STEEL STORAGE BOTTLES ARE SHOWN IN THE FOREGROUND. THE LARGE TANK IN THE CENTER IS THE REHEATER. THE ENGINES ARE ON THE OUTSIDE OF THE FRAME DIRECTLY OVER EACH RAIL.

Systems of Compressed Air Installation.

In the Hardie System the cars have 55 cubic feet of air storage, air being carried at 2500 pounds initial pressure in two nests of seven bottles each under the car and two long bottles within the car, placed longitudinally under the seats.

The air is reduced to 150 pounds per. square inch before entering the reheater and passing thence to the cylinders. The reservoirs within the cars are concealed and take up no passenger space.

Cars run one or two round trips without recharging, depending on the weight of traffic, weather conditions, and skill and judgment of the motorman.

On each platform are placed the operating devices, consisting of reversing levers,,throttle lever, air brake lever and the valve for shutting off air storage. A hand brake is also supplied for emergency.

The car seats thirty persons. The weight of the motor truck is 11000 pounds and total weight of car in working order 19000 pounds. The driving wheels 26 inches in diameter, are journaled in regular locomotive style and have the usual driving box spring suspension.

The relative positions of air reservoirs and reheaters are shown in cuts. When the air leaves the high pressure reservoir it passes through the pipe leading to the controller " stands" on the platforms where it is controlled by what is called the platform valve. From this point it passes to the reducing valve, which establishes the initial cylinder pressure of 150 pounds previously referred to, then from the reducing valve into the reheater before being receiv-

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ed into the cylinders.

The reducing valve is a diaphragm valve, specially constructed to deal with high pressures and , in addition to the ordinary action of such valves, a supplementary action is brought about by reducing the air pressure that is normally kept in the chamber above the valve head. When it is desired to quickly accelerate under heavy load, a movement of the brake valve handle to a given position discharges the air from the chamber above valve head and thus increasing the value of the coil spring beneath the diaphragm, opens the reducing valve in greater measure and temporarily increases the working pressure to 200 pounds while it is desirable to use that pressure in the cylinders.

The initial temperature of the fresh-charged water in the reheater is about 300 degrees F.

In this connection it may be said a car runs twice as far by heating the air as when the same amount of air was used cold.

The latest development of the Hardie improved cut-off valve gear is shown in side and end elevation. A supplementary cut-off arrangement is used. The motion of the cut-off valve is obtained through a floating system of levers moved by the cross head and link jointly. The motion is primarily a Stephenson link gear to operate the main valve.

The great advantage of having independent motors is generally recognized.

The impracticability of using steam as a motive force for street cars is likewise conceded. The choice, therefore, narrows in the

present state of the art, to that of very heavy and expensive electric storage battery cars or compressed air motors, when independent units are considered. It is not inconceivable or even unlikely that there are in New York, and in many other cities of consequence, cross town streets where the interest on the first cost of placing an underground electric or a cable system in the maze of pipes and conduits there holding a prior claim would continuously exceed the actual cost of operating a compressed air system of traction, when large plant units are considered.

It is a noticeable feature of the operation of the cars now running on 28th. and 29th. streets that the noise of exhaust that was objectionable in the working of the Hoadley-Knight motors is practically eliminated.

The cars both in acceleration under heavy load and when running at speed, are probably the least noisy of all cars operating on street railroads unless the cable car be excepted. At first thought it would seem that in exhausting air from an initial cylinder pressure of 150 pounds per. square inch there would be a pronounced sound from the cylinders as in the case of the locomotive.

It is apparent, however, that in dealing with a permanent gas such as air, where the expansion may be carried to the limit without loss by condensation, and where the exhaust is practically limitless in area because no fire is to be forced, the noise of the exhaust may be reduced in proportion to the expansion of air and freedom of exhaust, and becomes, as in this instance practically nothing.

This system differs from the Hoadley-Knight system in the

position of the engines only.

In the Hoadley-Knight system the engines were between the rails and power transmitted to the wheels by crank shafts.

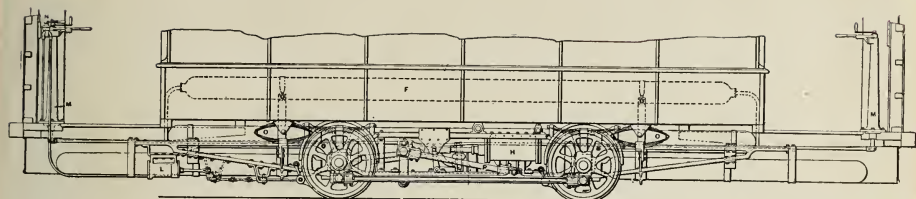


FIG. 2—ELEVATION OF CAR, SHOWING DETAILS OF EQUIPMENT.

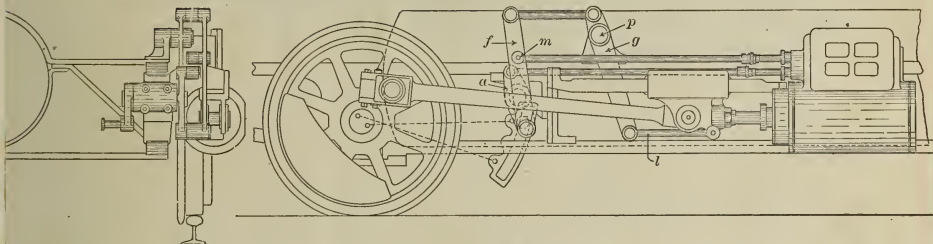


Fig. 3.—Hardie Air Motor.
Elevations Showing Valve Gear.

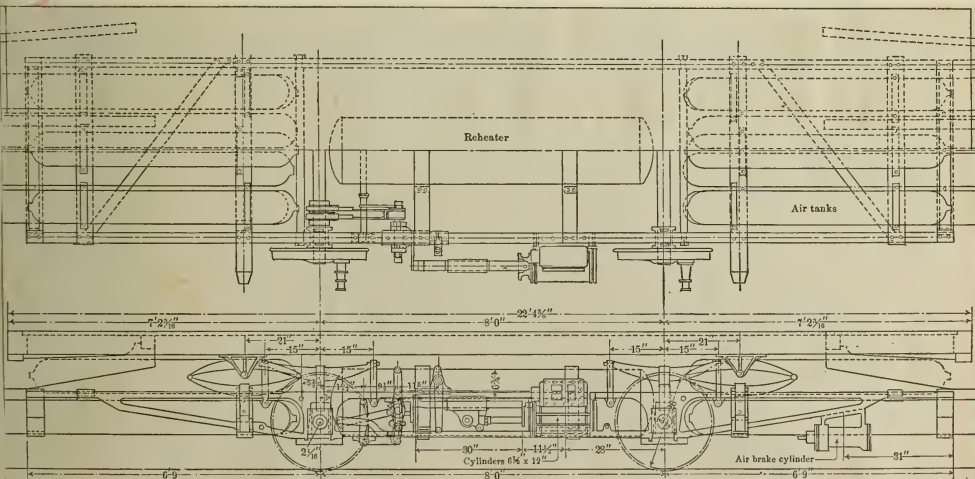


Fig. 2.—Hardie Compressed Air Motor.
Plan and Elevation.

The London Engineering Vol. 47, pages 163, 638, 685, 715 and Vol. 51 pages 327 and 419 and Vol. 58, page 313 describes the Popp system of compressed air in Paris. The first application of compressed air was to run clocks, using small cylinders with a piston. The cylinder is connected by tubes to the main air pipe. The impulse is given to the air in the mains every minute and in turn transmitted to each clock when the minute hand moves forward one space.

The plant was soon extended so as to furnish power for all sorts of purposes, ranging from the comparatively slight energy required for working a sewing machine, to the force necessary for driving printing machinery, electric light installations, elevators, etc.

To heat the air it is passed through a heating chamber where it is subjected to the action of a gas jet, and is also saturated by a spray of water which, it is claimed, nearly doubles the efficiency and prevents the formation of ice at the exhaust; a special type of engine, however, furnished with independent admission and exhaust valves, is being introduced to avoid the use of the heating device.

The heaters used by Mr. Popp were small cast iron stoves lined with fire clay heated by a gas jet or by a small coke fire.

Some results of experiments on heating are given. They were obtained from trials by Prof. Gutermuth. From these trials it was found that more than 70 per cent of the heat in the fuel was absorbed by the air and transformed into useful work.

Efficiency of Air Heating Stoves.

Nature of Heating stove.	Air surface. sq. ft.	Air heated per. hr. cu. ft.	Temperature of air in oven.		Heat absorbed per. hr. Total.	Per. sq. Per. lb.	
			Admiss- ion.	Exhaust.		ft. heat- ing sur- face	ft. coke.
Cast iron	14	20342	7	107	17900	1278	2032
Box stoves.	14	11054	7	184	17200	1228	2058
Wrt. iron coiled tubes.	46.3	38428	50	175	39200	830	2545

Table of Tests on Small Crank Steam Engines.

Engine used.	R. P. M.	B. H. P.	Temp. of air.		Air consumption per. B. H. P. hr in cu. ft.	Cold.	Heated.
			Admiss- ion.	Exhaust.			
2 H. P. Tayne.	242	3.77	25	-37	1186		
2 H. P. "	229	3.56	150				960
2 H. P. Journeaux.	169	2.10	10		1204		
2 H. P. "	148	2.27	150	0			695
1 H. P. "	283	1.035	150	34			845
1 H. P. Boulet.	149	1.10	165	18			815

The system employed in the propulsion of cars is the "Conti". The air is compressed to a relatively high pressure at a central station. It is then admitted to the main placed beneath the rails.

Branches lead the air nearly to the surface into automatic devices by which the car reservoirs can be charged at intervals along the line.

Value of Reheating Compressed Air Before Using as a Motive Power.

"Compressed Air" of October 1899 contains the following report on trials made at Magog, Quebec to test the economy effected by pre-heating compressed air by Prof. J.T. Nicolson.

These trials were made during the month of April 1899 at the Dominion Cotton Mills; Magog, Canada, where there is installed a 150 horse-power hydraulic air compressing plant on the system devised by G.H. Taylor of Montreal.

The trials were conducted under the auspices of Mr. Inslee, the Taylor Hydraulic Air Compressing Co., and the Dominion Cotton Mill Co. jointly, assisted by Prof. R. J. Burley of McGill University.

Experiments were made on five different methods of using compressed air in an ordinary steam engine of the Corliss type.

First. The air was supplied to the engine cold.

Second. Steam was injected into the air in the main pipe before supplying it to the engine.

Third. The air was injected into the water in a steam boiler and heated by mixing with the water and steam of the boiler before being supplied to the boiler.

Fourth. The air was blown upon the surface of the water in a steam boiler and heated by mixing with steam in same before being made to drive the engine.

Fifth. The air was passed through a tubular heating vessel and heated by a coke fire, afterward being used to work the engine.

For all the experiments the air was drawn at a pressure of 53 lbs. from the five inch main air pipe of the Taylor Air Compressor, which

supplies power to the mill, and was piped to a 12x30 Corliss engine supplied for the purpose of the trial by the Laurie Engine Co. of Montreal.

A friction brake was fitted on the fly-wheel of this engine and the engine in this way was worked up to its full power at about 75 R.P.M.

Connection was made to a Lancashire boiler seven feet in diameter by thirty feet long when it was desired to mix steam with the air for purposes of preheating.

When dry heating was resorted to, the air pipe was led through a heater on its way to the engine, having been previously blanked off from the steam boiler. This heater was designed by T. Nicolson and built by Messers The Laurie Engine Co. for these experiments, but as it was designed of such size as to heat the whole of the compressed air used in the mill, it was considerably larger than was required to heat the greatest quantity of air which could be used by the Corliss engine employed on the test.

Observations taken in the test without preheating were-

First. The temperature of air before entering engine.

Second. Temperature of air on leaving engine.

Third. The pressure of the entering air, indicator cards from each end of cylinder, revolutions and brake load.

The following are the results taken April 27th. 1899 with cold air. Entering air 66.5 degrees F., exhaust air -41 degrees F., R.P.M. 74.6 with cut-off about $\frac{1}{3}$ stroke. The I.H.P. was 27 and air used per hour 1671 lbs. or about 841 cu. ft. free air at 60. degrees F

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per. I.H.P. hr.

On another trial made under the same conditions 850 cu. ft. of free air was used per. I.H.P. hr.

In experiments made with dry heating the following observations were made:-

Temperature of the air before entering the heater; after passing up first row of tubes; upon leaving heater; and before entering engine. Also temperature of furnace and flue gases.

Gards were taken, also revolutions and brake horse power.

With air entering heater at a pressure of 53.5 pounds gauge and 58.2 degrees F. it was raised to 225 degrees F. after passing first row of tubes and to 363 degrees F. upon leaving the heater, but owing to lack of covering on pipe it fell to 287 degrees F. before entering engine where the pressure was 52.8 pounds gauge.

With these conditions and same cut off as in trial No. 1 with cold air the I.H.P. being 26.7 and revolutions 70 per. min., 1310 pounds of air per. hour was used which gives a consumption of 640 cu. ft. of free air per I.H.P. hr. a reduction of 210 cu. ft. of free air per. I.H.P. hr. due to preheating, or a saving of 24.7 per. cent is effected in the quantity of air used.

Tests were also made to determine the economy by heating the air by mixing it with steam from a boiler before allowing it to do work in the engine.

By mixing from 10 to 13 pounds of steam per horse power with the air the quantity of air was reduced from 850 cu. ft. to 300 to 500 cu. ft. per I.H.P. hr.

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50.1 degrees N. It was found to be 60.1 degrees N. after being 50.1 degrees N.

Journal of Interpersonal Violence 26(10) 1978-1997
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This method of preheating is not so economical as dry heating nor is it suitable for powers less than 50 horse-power unless waste steam is available.

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SERGEANT AIR REHEATER.

The accompanying cut represents the Sergeant Air Reheater in its simplest and most efficient form, the heater proper being made of two cast-iron shells, bolted together, having no tubes of any description to burn out or leak.

The heater is made in one size only, the extreme dimensions being 42 inches diameter by 54 inches high, the grate being 19 inches diameter.

From tests made with this heater it has been found capable of heating 340 cubic feet of free air per minute at 40 lbs. pressure to 360° F., giving a gain of 35 per cent, in the measured amount of work done by the air after passing through the heater, compared with the same volume of air when used cold.

A heater of this size will heat less air to a higher temperature, or more air to a lower temperature, than stated above; but, if it should be required to heat more than 400 cubic feet of free air per minute, to get the best economy, it is advisable to use the heaters in series, allowing about 400 cubic feet of free air per minute for each heater. The heater should be placed as near as possible to the point where the air is to be used, and the outlet pipe should be as short as possible and well covered, so that the air will retain its heat. Weight, 2,300 lbs.

Test of an Ingersoll Sargent, Class E, Air Compressor.

The object of this test was to determine the horse-power required to run the compressor and the efficiency of the compressor when compressing to different pressures.

To accomplish this purpose the compressor was run against pressures varying ten pounds at intervals of twenty-five minutes, during which time the pressure against the compressor was kept constant by means of a hand governed valve.

The revolutions of the compressor and engine were taken at intervals of five minutes and cards were taken from the engine and compressor simultaneously.

From this data the indicated horse-power of the two machines was calculated by the following formula $\frac{PLAN}{33000} = \text{I.H.P.}$ in which P = mean pressure of card, L = length of stroke in feet, A = effective area of piston and N = number of revolutions per minute.

The I.H.P. was calculated for head and crank ends separately.

The constants for the 10x10 air compressor are, for head end

$$\frac{L.A.}{33000} = .001983 \text{ and for crank end } \frac{L.A.}{33000} = .001923.$$

The constants for the 10x10 Ide engine used are for head end

$$\frac{L.A.}{33000} = .001983 \text{ and for crank end } \frac{L.A.}{33000} = .001913.$$

Now, having the I.H.P. of both engine and compressor, the mechanical efficiency was found by dividing the I.H.P. of the compressor by the I.H.P. of the engine.

The flow of cooling water through the water jacket of the compressor was kept constant and measured by means of a meter and found to be

61.35 cubic feet per hour.

In order to show conditions under which test was run a thermometer was inserted in the pipe leading from the compressor to tank and temperature noted at intervals of five minutes as was the temperature of the room and outside air and steam pressure.

The following sheets contain the tabulated results and the original data showing conditions under which test was run; also characteristic cards from the engine and compressor.

The following photographs show the system of belting used, air receivers and reducing motions used.

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No.	Time.	Engine	Comp.	Steam Pressure.	Air Press.	Temperatures		
		R. P. M.	R. P. M.			Exhaust.	Cut- side.	Room.
1.	8:00	301	151	110	0	80	45	76
2.	8:05	297	150	111	0	80	45	76
3.	8:10	299	151	108	0	80	45	76
4.	8:15	300	152	107	0	80	45	77
5.	8:20	300	152	104	0	80	45	78
6.	8:25	298	151	104	10	140	45	77
7.	8:30	297	150	105	10	141	45	77
8.	8:35	300	152	105	10	142	45	78
9.	8:40	300	151	106	10	140	45	78
10.	8:45	300	151	104	10	139	45	77
11.	8:50	300	151	104	20	170	45	78
12.	8:55	298	150	105	20	174	45	78
13.	9:00	302	152	107	20	175	45	78
14.	9:05	300	151	108	20	176	45	78
15.	9:10	300	151	108	20	176	45	78
16.	9:15	298	150	106	30	199	45	78
17.	9:20	299	150	105	30	203	45	78
18.	9:25	299	150	108	30	204	45	78
19.	9:30	299	150	113	30	205	45	78
20.	9:35	299	150	105	30	204	45	78
21.	9:40	299	151	103	40	231	45	78
22.	9:45	299	150	108	40	232	45	78
23.	9:50	299	151	106	40	233	45	78
24.	9:55	300	151	106	40	233	45	77

No.	Time.	Engine	Comp.	Steam	Air	Temperatures.	
		R. P. M.	R. P. M.	Pressure.	Press.	Exhaust.	Out- Room. side.
25.	10:00	299	151	107	40	233	45 78
26.	10:05	299	150	106	50	252	45 77
27.	10:10	299	151	106	50	253	45 77
28.	10:15	299	150	108	50	253	45 78
29.	10:20	299	151	105	50	253	45 78
30.	10:25	299	151	103	50	254	45 77
31.	10:30	299	151	108	60	263	45 78
32.	10:35	300	151	107	60	270	45 78
33.	10:40	299	151	109	60	270	45 78
34.	10:45	299	150	109	60	271	45 78
35.	10:50	299	150	108	60	272	45 78
36.	10:55	299	150	108	70	279	45 78
37.	11:00	301	151	109	70	282	45 78
38.	11:05	299	150	108	70	282	45 78
39.	11:10	299	151	108	70	282	45 78
40.	11:15	298	150	108	70	282	45 78
41.	11:20	298	150	108	80	286	45 78
42.	11:25	298	150	108	80	287	45 78
43.	11:30	298	150	108	80	288	45 78
44.	11:35	299	150	109	80	289	45 78
45.	11:40	298	150	105	80	290	45 78
46.	11:45	298	150	108	90	297	45 78
47.	11:50	298	151	108	90	297	45 78
48.	11:55	298	150	103	90	297	45 78

No.	Time	Engine.	Comp.	Steam	Air	Temperatures.		Room.
		R. P. M.	R. P. M.	Pressure.	Press.	Exhaust.	Out side.	
49.	12:00	298	151	107	90	298	42	78
50.	12:05	298	150	103	90	298	42	78
51.	12:10	299	150	100	100	310	42	78
52.	12:15	299	150	100	100	311	41	79
53.	12:20	299	151	100	100	311	41	78
54.	12:25	298	150	103	100	312	41	78
55.	12:30	298	150	101	100	312	41	78

Year	1900	1901	1902	1903	1904	1905	1906
1	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100

No.	Time.	Engine I. H. P.	Comp ressor. I. H. P.	Mech. Eff. %	Average Air Press Mech. Eff. lbs. per sq. in.
1.	8:00	8.36			0
2.	8:05	7.82			0
3.	8:10	7.63			0
4.	8:15	8.71			0
5.	8:20	7.79			0
6.	8:25	13.16	7.04	53.3	10
7.	8:30	14.49	6.90	47.6	10
8.	8:35	13.78	7.15	51.9	50.7 10
9.	8:40	13.78	7.12	51.6	10
10.	8:45	14.42	7.12	49.3	10
11.	8:50	18.68	10.02	53.5	20
12.	8:55	17.11	10.50	61.3	20
13.	9:00	16.14	10.11	62.9	57.7 20
14.	9:05	18.14	10.00	55.1	20
15.	9:10	17.89	10.02	56.0	20
16.	9:15	19.39	12.40	63.9	30
17.	9:20	19.55	12.27	62.7	30
18.	9:25	19.10	12.25	64.1	62.2 30
19.	9:30	20.64	12;32	59.6	30
20.	9:35	19.98	12;20	61.0	30
21.	9:40	20.97	14.31	68.2	40
22.	9:45	20.99	14.04	66.8	40
23.	9:50	20.24	14.49	71.5	68.8 40
24.	9:55	20.61	14.45	70.1	40

Year	Month	Day	Time	Location	Altitude
1900	Jan	1	10:00	1000	1000
1900	Jan	2	10:00	1000	1000
1900	Jan	3	10:00	1000	1000
1900	Jan	4	10:00	1000	1000
1900	Jan	5	10:00	1000	1000
1900	Jan	6	10:00	1000	1000
1900	Jan	7	10:00	1000	1000
1900	Jan	8	10:00	1000	1000
1900	Jan	9	10:00	1000	1000
1900	Jan	10	10:00	1000	1000
1900	Jan	11	10:00	1000	1000
1900	Jan	12	10:00	1000	1000
1900	Jan	13	10:00	1000	1000
1900	Jan	14	10:00	1000	1000
1900	Jan	15	10:00	1000	1000
1900	Jan	16	10:00	1000	1000
1900	Jan	17	10:00	1000	1000
1900	Jan	18	10:00	1000	1000
1900	Jan	19	10:00	1000	1000
1900	Jan	20	10:00	1000	1000
1900	Jan	21	10:00	1000	1000
1900	Jan	22	10:00	1000	1000
1900	Jan	23	10:00	1000	1000
1900	Jan	24	10:00	1000	1000
1900	Jan	25	10:00	1000	1000
1900	Jan	26	10:00	1000	1000
1900	Jan	27	10:00	1000	1000
1900	Jan	28	10:00	1000	1000
1900	Jan	29	10:00	1000	1000
1900	Jan	30	10:00	1000	1000
1900	Jan	31	10:00	1000	1000

No.	Time.	Engine I. H. P.	Compressor I. H. P.	Mech. Eff. %	Average Air Press. Mech. Eff. lbs. per sq. in.	
25.	10:00	20.97	14.14	67.5		40
26.	10:05	21.64	13.74	63.4		50
27.	10:10	23.24	15.17	65.2		50
28.	10:15	22.50	15.95	70.9	67.0	50
29.	10:20	21.68	15.01	60.2		50
30.	10:25	22.32	15.17	66.4		50
31.	10:30	22.75	15.88	69.9		60
32.	10:35	22.28	16.77	73.2		60
33.	10:40	23.32	16.24	69.0	70.1	60
34.	10:45	22.54	15.77	69.9		60
35.	10:50	23.67	15.78	66.8		60
36.	10:55	26.61	17.89	67.1		70
37.	11:00	24.77	15.68	63.3		70
38.	11:05	25.57	16.12	63.0	66.3	70
39.	11:10	26.08	17.14	65.7		70
40.	11:15	23.76	17.12	72.0		70
41.	11:20	25.99	17.35	66.7		80
42.	11:25	23.41	18.23	77.8		80
43.	11:30	23.37	17.53	75.0	75.4	80
44.	11:35	26.92	18.79	69.3		80
45.	11:40	26.76	18.58	69.4		80
46.	11:45	28.70	20.17	70.3		90
47.	11:50	27.35	20.31	74.2		90
48.	11:55	26.31	18.80	71.4	70.2	90

No.	Time	Engine I.H.P.	Compressor I.H.P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per sq. in.
40.	12:00	27.35	18.35	67.1		90
50.	12:05	27.54	18.77	68.1		90
51.	12:10	29.53	21.22	71.8		100
52.	12:15	29.52	20.52	69.5		100
53.	12:20	29.35	21.22	72.3	71.7	100
54.	12:25	29.70	21.36	72.6		100
55.	12:30	30.01	21.50	71.6		100

After test number ⁵³ was completed the clearance was found unequal as shown by the cards. This was adjusted by lengthening the piston rod until correct position was obtained as shown by testing with indicator.

Test number two was then run with the following results.

Year	Month	Day	Time	Location	Remarks
1901	Jan	1	12:00	100 ft	100 ft
1901	Jan	2	12:00	100 ft	100 ft
1901	Jan	3	12:00	100 ft	100 ft
1901	Jan	4	12:00	100 ft	100 ft
1901	Jan	5	12:00	100 ft	100 ft
1901	Jan	6	12:00	100 ft	100 ft
1901	Jan	7	12:00	100 ft	100 ft
1901	Jan	8	12:00	100 ft	100 ft
1901	Jan	9	12:00	100 ft	100 ft
1901	Jan	10	12:00	100 ft	100 ft
1901	Jan	11	12:00	100 ft	100 ft
1901	Jan	12	12:00	100 ft	100 ft
1901	Jan	13	12:00	100 ft	100 ft
1901	Jan	14	12:00	100 ft	100 ft
1901	Jan	15	12:00	100 ft	100 ft
1901	Jan	16	12:00	100 ft	100 ft
1901	Jan	17	12:00	100 ft	100 ft
1901	Jan	18	12:00	100 ft	100 ft
1901	Jan	19	12:00	100 ft	100 ft
1901	Jan	20	12:00	100 ft	100 ft
1901	Jan	21	12:00	100 ft	100 ft
1901	Jan	22	12:00	100 ft	100 ft
1901	Jan	23	12:00	100 ft	100 ft
1901	Jan	24	12:00	100 ft	100 ft
1901	Jan	25	12:00	100 ft	100 ft
1901	Jan	26	12:00	100 ft	100 ft
1901	Jan	27	12:00	100 ft	100 ft
1901	Jan	28	12:00	100 ft	100 ft
1901	Jan	29	12:00	100 ft	100 ft
1901	Jan	30	12:00	100 ft	100 ft
1901	Jan	31	12:00	100 ft	100 ft

After each number was recorded the distance was found measured
 as shown by the code. This was repeated as frequently as possible
 and until contact was obtained as shown by the following results.

Test number two was done with the following results.



10-2-00-2M-0

BOILER PRES. 108

R. P. M. 299

SCALE 60

$A = .97$ "

M.E.P. = 21.9

I.H.P. = 12.67

Crosby 3-inch Drum

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 38

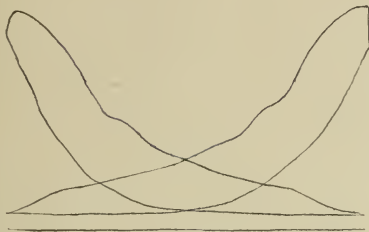
END

CYLINDER 10x10

$A = .96$ "

M.E.P. = 21.66

I.H.P. = 12.9



1-15-00-1M-0

BOILER PRES. 70

R. P. M. 150

SCALE 60

$A = 1.23$ "

M.E.P. = 24

I.H.P. = 7.13

Thompson 1 1/2-inch Drum

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 39

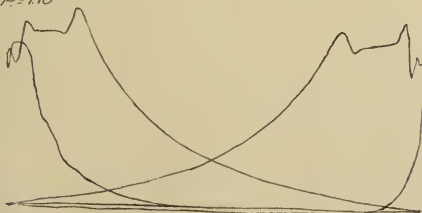
END

CYLINDER 10x10

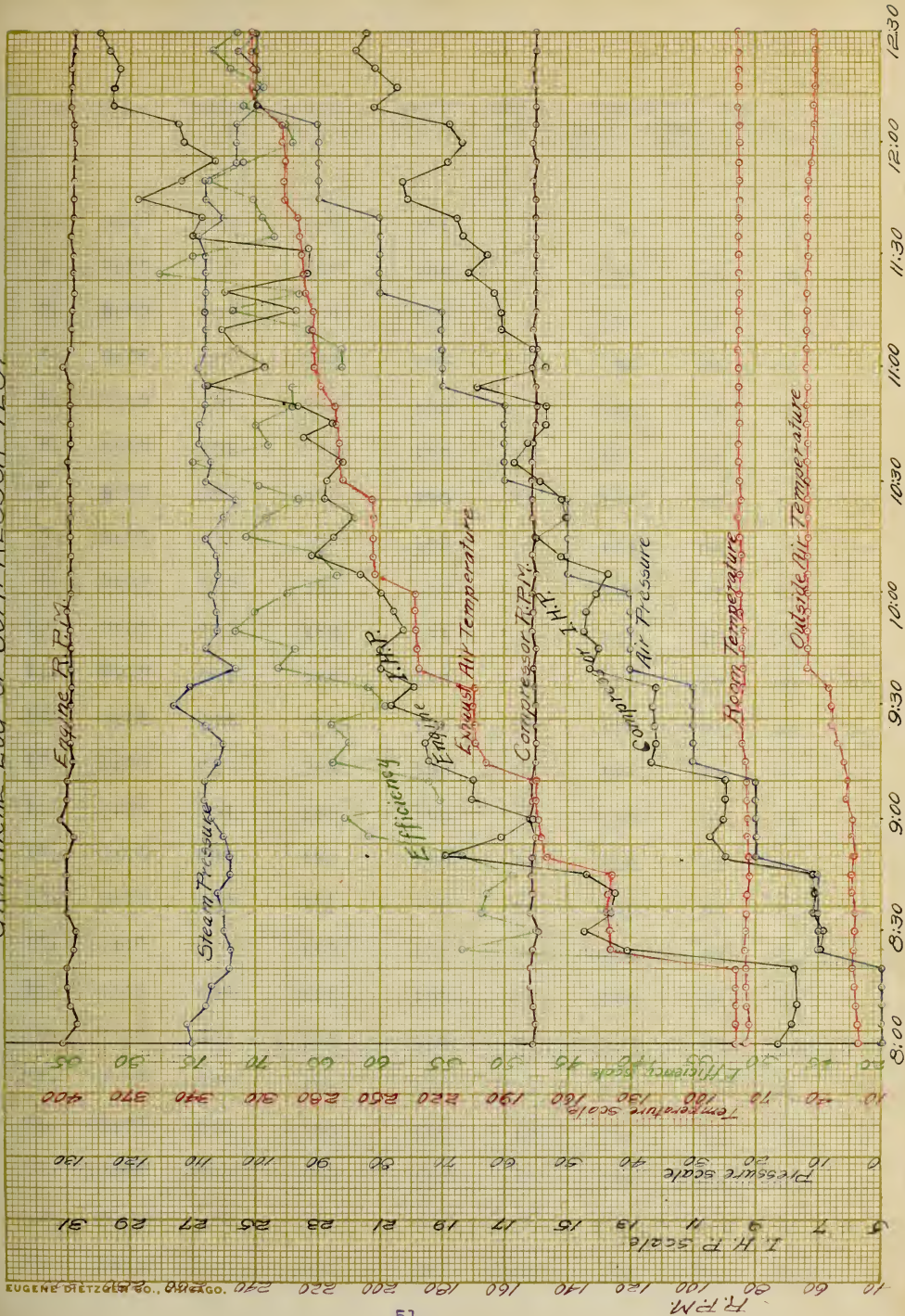
$A = 1.62$ "

M.E.P. = 31.2

I.H.P. = 8.99



GRAPHICAL LOG OF COMPRESSOR TEST



No.	Time.	Engine R. P. M.	Comp. R. P. M.	Steam Press.	Air Press.	Temperatures.			
						Exhaust Air.	Out side.	Room.	Exhaust water.
1.	8:20	302	153	111	0	90	26	72	56
2.	8:25	299	151	109	0	86	26	72	56
3.	8:30	301	152	109	0	87	26	72	55
4.	8:35	301	152	108	0	86	26	72	55
5.	8:40	301	144	109	0	84	26	72	55
6.	8:45	301	151	110	10	141	26	72	55
7.	8:50	299	152	110	10	146	26	72	55
8.	8:55	301	150	110	10	144	26	72	54
9.	9:00	299	151	110	10	143	27	72	56
10.	9:05	299	152	111	10	142	27	72	56
11.	9:10	301	151	110	20	172	27	72	56
12.	9:15	298	150	110	20	178	27	72	56
13.	9:20	299	152	110	20	178	27	73	56
14.	9:25	301	151	110	20	180	27	74	56
15.	9:30	298	150	110	20	180	27	74	56
16.	9:35	299	151	110	30	200	28	74	56
17.	9:40	298	150	107	30	204	28	74	56
18.	9:45	299	151	105	30	206	28	74	57
19.	9:50	298	150	110	30	209	28	74	57
20.	9:55	298	151	109	30	210	28	74	57
21.	10:00	299	150	110	40	221	28	75	57
22.	10:05	298	150	110	40	224	28	75	57
23.	10:10	299	150	107	40	225	28	75	57
24.	10:15	299	150	109	40	226	28	75	57

Year	Month	Day	Time	Location	Event	Remarks
1901	Jan	1	10:00	St. Paul	Arrival	From New York
1901	Jan	2	10:00	St. Paul	Departure	To Chicago
1901	Jan	3	10:00	St. Paul	Arrival	From Chicago
1901	Jan	4	10:00	St. Paul	Departure	To New York
1901	Jan	5	10:00	St. Paul	Arrival	From New York
1901	Jan	6	10:00	St. Paul	Departure	To Chicago
1901	Jan	7	10:00	St. Paul	Arrival	From Chicago
1901	Jan	8	10:00	St. Paul	Departure	To New York
1901	Jan	9	10:00	St. Paul	Arrival	From New York
1901	Jan	10	10:00	St. Paul	Departure	To Chicago
1901	Jan	11	10:00	St. Paul	Arrival	From Chicago
1901	Jan	12	10:00	St. Paul	Departure	To New York
1901	Jan	13	10:00	St. Paul	Arrival	From New York
1901	Jan	14	10:00	St. Paul	Departure	To Chicago
1901	Jan	15	10:00	St. Paul	Arrival	From Chicago
1901	Jan	16	10:00	St. Paul	Departure	To New York
1901	Jan	17	10:00	St. Paul	Arrival	From New York
1901	Jan	18	10:00	St. Paul	Departure	To Chicago
1901	Jan	19	10:00	St. Paul	Arrival	From Chicago
1901	Jan	20	10:00	St. Paul	Departure	To New York
1901	Jan	21	10:00	St. Paul	Arrival	From New York
1901	Jan	22	10:00	St. Paul	Departure	To Chicago
1901	Jan	23	10:00	St. Paul	Arrival	From Chicago
1901	Jan	24	10:00	St. Paul	Departure	To New York
1901	Jan	25	10:00	St. Paul	Arrival	From New York
1901	Jan	26	10:00	St. Paul	Departure	To Chicago
1901	Jan	27	10:00	St. Paul	Arrival	From Chicago
1901	Jan	28	10:00	St. Paul	Departure	To New York
1901	Jan	29	10:00	St. Paul	Arrival	From New York
1901	Jan	30	10:00	St. Paul	Departure	To Chicago
1901	Jan	31	10:00	St. Paul	Arrival	From Chicago

No.	Time.	Engine R. P. M.	Comp. R. P. M.	Steam press.	Air Press.	Temperatures.			
						Exhaust Air.	Out side.	Room.	Exhaust water.
25.	10:20	298	150	109	40	227	28	75	57
26.	10:25	297	149	108	50	244	28	76	58
27.	10:30	297	150	110	50	249	28	76	58
28.	10:35	298	150	102	50	250	28	76	59
29.	10:40	298	150	110	50	252	28	76	58
30.	10:45	299	149	110	50	252	28	76	58
31.	10:50	300	151	110	60	262	28	76	58
32.	10:55	301	151	110	60	267	28	76	58
33.	11:00	298	150	110	60	267	28	76	58
34.	11:05	298	150	110	60	270	28	76	59
35.	11:10	298	150	110	60	270	28	76	59
36.	11:15	297	149	110	70	275	28	77	59
37.	11:20	298	150	110	70	278	28	77	59
38.	11:25	299	151	110	70	280	28	77	59
39.	11:30	297	149	110	70	280	29	78	60
40.	11:35	300	151	110	70	280	29	78	60
41.	11:40	298	150	110	80	286	29	78	60
42.	11:45	297	149	110	80	288	29	78	60
43.	11:50	297	149	110	80	290	29	78	61
44.	11:55	298	151	110	80	290	29	78	61
45.	12:00	296	149	110	80	292	29	78	61
46.	12:05	298	150	110	90	302	29	78	62
47.	12:10	297	149	110	90	304	29	78	61
48.	12:15	297	149	107	90	304	29	78	61

Locality	Altitude	Temperature	Humidity	Wind	Clouds	Soil	Vegetation	Time	Date
1	100	25	80	SE	100	100	100	10:00	1950
2	150	20	75	SE	100	100	100	10:15	1950
3	200	15	70	SE	100	100	100	10:30	1950
4	250	10	65	SE	100	100	100	10:45	1950
5	300	5	60	SE	100	100	100	11:00	1950
6	350	0	55	SE	100	100	100	11:15	1950
7	400	-5	50	SE	100	100	100	11:30	1950
8	450	-10	45	SE	100	100	100	11:45	1950
9	500	-15	40	SE	100	100	100	12:00	1950
10	550	-20	35	SE	100	100	100	12:15	1950
11	600	-25	30	SE	100	100	100	12:30	1950
12	650	-30	25	SE	100	100	100	12:45	1950
13	700	-35	20	SE	100	100	100	13:00	1950
14	750	-40	15	SE	100	100	100	13:15	1950
15	800	-45	10	SE	100	100	100	13:30	1950
16	850	-50	5	SE	100	100	100	13:45	1950
17	900	-55	0	SE	100	100	100	14:00	1950
18	950	-60	-5	SE	100	100	100	14:15	1950
19	1000	-65	-10	SE	100	100	100	14:30	1950
20	1050	-70	-15	SE	100	100	100	14:45	1950
21	1100	-75	-20	SE	100	100	100	15:00	1950
22	1150	-80	-25	SE	100	100	100	15:15	1950
23	1200	-85	-30	SE	100	100	100	15:30	1950
24	1250	-90	-35	SE	100	100	100	15:45	1950
25	1300	-95	-40	SE	100	100	100	16:00	1950
26	1350	-100	-45	SE	100	100	100	16:15	1950
27	1400	-105	-50	SE	100	100	100	16:30	1950
28	1450	-110	-55	SE	100	100	100	16:45	1950
29	1500	-115	-60	SE	100	100	100	17:00	1950
30	1550	-120	-65	SE	100	100	100	17:15	1950
31	1600	-125	-70	SE	100	100	100	17:30	1950
32	1650	-130	-75	SE	100	100	100	17:45	1950
33	1700	-135	-80	SE	100	100	100	18:00	1950
34	1750	-140	-85	SE	100	100	100	18:15	1950
35	1800	-145	-90	SE	100	100	100	18:30	1950
36	1850	-150	-95	SE	100	100	100	18:45	1950
37	1900	-155	-100	SE	100	100	100	19:00	1950
38	1950	-160	-105	SE	100	100	100	19:15	1950
39	2000	-165	-110	SE	100	100	100	19:30	1950
40	2050	-170	-115	SE	100	100	100	19:45	1950
41	2100	-175	-120	SE	100	100	100	20:00	1950
42	2150	-180	-125	SE	100	100	100	20:15	1950
43	2200	-185	-130	SE	100	100	100	20:30	1950
44	2250	-190	-135	SE	100	100	100	20:45	1950
45	2300	-195	-140	SE	100	100	100	21:00	1950
46	2350	-200	-145	SE	100	100	100	21:15	1950
47	2400	-205	-150	SE	100	100	100	21:30	1950
48	2450	-210	-155	SE	100	100	100	21:45	1950
49	2500	-215	-160	SE	100	100	100	22:00	1950
50	2550	-220	-165	SE	100	100	100	22:15	1950
51	2600	-225	-170	SE	100	100	100	22:30	1950
52	2650	-230	-175	SE	100	100	100	22:45	1950
53	2700	-235	-180	SE	100	100	100	23:00	1950
54	2750	-240	-185	SE	100	100	100	23:15	1950
55	2800	-245	-190	SE	100	100	100	23:30	1950
56	2850	-250	-195	SE	100	100	100	23:45	1950
57	2900	-255	-200	SE	100	100	100	24:00	1950
58	2950	-260	-205	SE	100	100	100	24:15	1950
59	3000	-265	-210	SE	100	100	100	24:30	1950
60	3050	-270	-215	SE	100	100	100	24:45	1950
61	3100	-275	-220	SE	100	100	100	25:00	1950
62	3150	-280	-225	SE	100	100	100	25:15	1950
63	3200	-285	-230	SE	100	100	100	25:30	1950
64	3250	-290	-235	SE	100	100	100	25:45	1950
65	3300	-295	-240	SE	100	100	100	26:00	1950
66	3350	-300	-245	SE	100	100	100	26:15	1950
67	3400	-305	-250	SE	100	100	100	26:30	1950
68	3450	-310	-255	SE	100	100	100	26:45	1950
69	3500	-315	-260	SE	100	100	100	27:00	1950
70	3550	-320	-265	SE	100	100	100	27:15	1950
71	3600	-325	-270	SE	100	100	100	27:30	1950
72	3650	-330	-275	SE	100	100	100	27:45	1950
73	3700	-335	-280	SE	100	100	100	28:00	1950
74	3750	-340	-285	SE	100	100	100	28:15	1950
75	3800	-345	-290	SE	100	100	100	28:30	1950
76	3850	-350	-295	SE	100	100	100	28:45	1950
77	3900	-355	-300	SE	100	100	100	29:00	1950
78	3950	-360	-305	SE	100	100	100	29:15	1950
79	4000	-365	-310	SE	100	100	100	29:30	1950
80	4050	-370	-315	SE	100	100	100	29:45	1950
81	4100	-375	-320	SE	100	100	100	30:00	1950
82	4150	-380	-325	SE	100	100	100	30:15	1950
83	4200	-385	-330	SE	100	100	100	30:30	1950
84	4250	-390	-335	SE	100	100	100	30:45	1950
85	4300	-395	-340	SE	100	100	100	31:00	1950
86	4350	-400	-345	SE	100	100	100	31:15	1950
87	4400	-405	-350	SE	100	100	100	31:30	1950
88	4450	-410	-355	SE	100	100	100	31:45	1950
89	4500	-415	-360	SE	100	100	100	32:00	1950
90	4550	-420	-365	SE	100	100	100	32:15	1950
91	4600	-425	-370	SE	100	100	100	32:30	1950
92	4650	-430	-375	SE	100	100	100	32:45	1950
93	4700	-435	-380	SE	100	100	100	33:00	1950
94	4750	-440	-385	SE	100	100	100	33:15	1950
95	4800	-445	-390	SE	100	100	100	33:30	1950
96	4850	-450	-395	SE	100	100	100	33:45	1950
97	4900	-455	-400	SE	100	100	100	34:00	1950
98	4950	-460	-405	SE	100	100	100	34:15	1950
99	5000	-465	-410	SE	100	100	100	34:30	1950
100	5050	-470	-415	SE	100	100	100	34:45	1950

No.	Time.	Engine	Comp.	Steam	Air	Temperatures.			
		R. P. M.	R. P. M.			Exhaust	Out Room.	Exhaust	
				Press.	Press.	Air.	side.	water.	
49.	12:20	297	149	107	90	303	29	78	61
50.	12:25	297	149	108	90	304	30	78	61
51.	12:30	297	150	109	100	305	30	78	61
52.	12:35	297	149	107	100	308	30	78	61
53.	12:40	299	151	107	100	310	30	78	62
54.	12:45	297	149	108	100	311	30	78	61
55.	12:50	298	150	108	100	312	30	78	61

Alt.	Time	Temp.	Wind	Cloud	Bar.	Hum.	Dir.	Dist.	Remarks
10	10:00	67	145	100	100	100	100	100	
10	10:15	67	145	100	100	100	100	100	
10	10:30	67	145	100	100	100	100	100	
10	10:45	67	145	100	100	100	100	100	
10	11:00	67	145	100	100	100	100	100	
10	11:15	67	145	100	100	100	100	100	
10	11:30	67	145	100	100	100	100	100	
10	11:45	67	145	100	100	100	100	100	
10	12:00	67	145	100	100	100	100	100	
10	12:15	67	145	100	100	100	100	100	
10	12:30	67	145	100	100	100	100	100	
10	12:45	67	145	100	100	100	100	100	
10	13:00	67	145	100	100	100	100	100	
10	13:15	67	145	100	100	100	100	100	
10	13:30	67	145	100	100	100	100	100	
10	13:45	67	145	100	100	100	100	100	
10	14:00	67	145	100	100	100	100	100	
10	14:15	67	145	100	100	100	100	100	
10	14:30	67	145	100	100	100	100	100	
10	14:45	67	145	100	100	100	100	100	
10	15:00	67	145	100	100	100	100	100	
10	15:15	67	145	100	100	100	100	100	
10	15:30	67	145	100	100	100	100	100	
10	15:45	67	145	100	100	100	100	100	
10	16:00	67	145	100	100	100	100	100	
10	16:15	67	145	100	100	100	100	100	
10	16:30	67	145	100	100	100	100	100	
10	16:45	67	145	100	100	100	100	100	
10	17:00	67	145	100	100	100	100	100	
10	17:15	67	145	100	100	100	100	100	
10	17:30	67	145	100	100	100	100	100	
10	17:45	67	145	100	100	100	100	100	
10	18:00	67	145	100	100	100	100	100	
10	18:15	67	145	100	100	100	100	100	
10	18:30	67	145	100	100	100	100	100	
10	18:45	67	145	100	100	100	100	100	
10	19:00	67	145	100	100	100	100	100	
10	19:15	67	145	100	100	100	100	100	
10	19:30	67	145	100	100	100	100	100	
10	19:45	67	145	100	100	100	100	100	
10	20:00	67	145	100	100	100	100	100	
10	20:15	67	145	100	100	100	100	100	
10	20:30	67	145	100	100	100	100	100	
10	20:45	67	145	100	100	100	100	100	
10	21:00	67	145	100	100	100	100	100	
10	21:15	67	145	100	100	100	100	100	
10	21:30	67	145	100	100	100	100	100	
10	21:45	67	145	100	100	100	100	100	
10	22:00	67	145	100	100	100	100	100	
10	22:15	67	145	100	100	100	100	100	
10	22:30	67	145	100	100	100	100	100	
10	22:45	67	145	100	100	100	100	100	
10	23:00	67	145	100	100	100	100	100	
10	23:15	67	145	100	100	100	100	100	
10	23:30	67	145	100	100	100	100	100	
10	23:45	67	145	100	100	100	100	100	
10	24:00	67	145	100	100	100	100	100	

No.	Time.	Engine I. H. P.	Compress. I. H. P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per sq. in.
1.	8:20	10.2				0
2.	8:25	8.4				0
3.	8:30	9.3				0
4.	8:35	9.4				0
5.	8:40	9.9				0
6.	8:45	16.1	6.71	41.6		10
7.	8:50	15.2	6.61	40.8		10
8.	8:55	15.6	6.65	42.6	42.9	10
9.	9:00	14.9	6.75	45.3		10.
10.	9:05	15.4	8.87	44.6		10
11.	9:10	17.2	9.01	52.3		20
12.	9:15	17.2	8.87	51.5		20
13.	9:20	17.6	8.88	50.4	51.9	20
14.	9:25	16.9	9.42	55.7		20
15.	9:30	17.4	8.68	50.0		20
16.	9:35	18.6	10.82	58.2		30
17.	9:40	19.6	10.97	54.8		30
18.	9:45	18.9	10.82	57.1	55.8	30
19.	9:50	19.4	10.82	55.4		30
20.	9:55	19.3	10.74	55.7		30
21.	10:00	21.4	12.27	57.3		40
22.	10:05	20.3	12.15	59.8		40
23.	10:10	20.8	12.55	60.3	59.0	40
24.	10:15	20.3	12.30	60.6		40

Year	Month	Day	Time	Temp	Wind	Humid	Barom	Clouds	Remarks
1901	Jan	1	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	2	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	3	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	4	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	5	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	6	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	7	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	8	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	9	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	10	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	11	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	12	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	13	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	14	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	15	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	16	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	17	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	18	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	19	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	20	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	21	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	22	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	23	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	24	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	25	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	26	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	27	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	28	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	29	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	30	08:00	34.0	10.0	75.0	30.10	0	
1901	Jan	31	08:00	34.0	10.0	75.0	30.10	0	

No.	Time.	Engine I. H. P.	Compress. I. H. P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per sq. in.
25.	10:20	21.4	12.28	57.3		40
26.	10:25	22.6	13.78	58.3		50
27.	10:30	22.7	13.44	59.2		50
28.	10:35	23.3	13.64	58.5	60.3	50
29.	10:40	21.8	13.72	62.9		50
30.	10:45	22.3	14.04	62.9		50
31.	10:50	24.5	14.62	61.0		60
32.	10:55	24.5	14.46	59.0		60
33.	11:00	23.2	14.87	64.1	61.8	60
34.	11:05	23.9	14.62	61.3		60
35.	11:10	23.2	14.82	63.8		60
36.	11:15	24.9	17.45	70.0		70
37.	11:20	24.2	17.17	70.9		70
38.	11:25	25.4	17.25	67.9	68.7	70
39.	11:30	23.9	16.73	70.0		70
40.	11:35	25.1	16.31	65.0		70
41.	11:40	25.9	17.22	66.4		80
42.	11:45	27.6	16.52	59.8		80
43.	11:50	26.4	17.44	66.0	63.7	80
44.	11:55	25.8	17.90	69.4		80
45.	12:00	25.7	16.17	62.9		80
46.	12:05	27.9	18.32	65.6		90
47.	12:10	27.8	18.16	65.3		90
48.	12:15	28.8	17.35	60.2	63.7	90

No.	Time	Light	Distance	Depth	Temperature	Wind
10	10:00	4.20	10.00	10.0	10.0	10.0
11	10:05	4.20	10.00	10.0	10.0	10.0
12	10:10	4.20	10.00	10.0	10.0	10.0
13	10:15	4.20	10.00	10.0	10.0	10.0
14	10:20	4.20	10.00	10.0	10.0	10.0
15	10:25	4.20	10.00	10.0	10.0	10.0
16	10:30	4.20	10.00	10.0	10.0	10.0
17	10:35	4.20	10.00	10.0	10.0	10.0
18	10:40	4.20	10.00	10.0	10.0	10.0
19	10:45	4.20	10.00	10.0	10.0	10.0
20	10:50	4.20	10.00	10.0	10.0	10.0
21	10:55	4.20	10.00	10.0	10.0	10.0
22	11:00	4.20	10.00	10.0	10.0	10.0
23	11:05	4.20	10.00	10.0	10.0	10.0
24	11:10	4.20	10.00	10.0	10.0	10.0
25	11:15	4.20	10.00	10.0	10.0	10.0
26	11:20	4.20	10.00	10.0	10.0	10.0
27	11:25	4.20	10.00	10.0	10.0	10.0
28	11:30	4.20	10.00	10.0	10.0	10.0
29	11:35	4.20	10.00	10.0	10.0	10.0
30	11:40	4.20	10.00	10.0	10.0	10.0
31	11:45	4.20	10.00	10.0	10.0	10.0
32	11:50	4.20	10.00	10.0	10.0	10.0
33	11:55	4.20	10.00	10.0	10.0	10.0
34	12:00	4.20	10.00	10.0	10.0	10.0
35	12:05	4.20	10.00	10.0	10.0	10.0
36	12:10	4.20	10.00	10.0	10.0	10.0
37	12:15	4.20	10.00	10.0	10.0	10.0
38	12:20	4.20	10.00	10.0	10.0	10.0

No.	Time.	Engine I. H. P.	Compress. I. H. P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per. sq. in.
49.	12:20	27.7	17.96	64.8		90
50.	12:25	26.9	16.86	62.6		90
51.	12:30	27.3	19.30	70.7		100
52.	12:35	27.8	19.10	68.7		100
53.	12:40	27.3	18.50	67.8	68.1	100
54.	12:45	27.1	20.00	73.8		100
55.	12:50	30.3	18.13	59.8		100

In test number two the head end card was found to be defective so the exhaust valves were examined, and the regulating by-pass was closed and test number three was conducted with satisfactory results.

[illegible][illegible]

10-2-00-2M-0

BOILER PRES. 110

R. P. M. 299

SCALE 60

Area - 97 sq"

M.E.P. - 22.17

I.H.P. - 13.1

Crosby 2-inch Drum

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 38

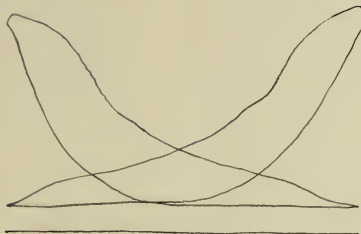
END

CYLINDER 10x10

Area - 99 sq"

M.E.P. - 61.49

I.H.P. - 12.3



1-15-00-1M-0

BOILER PRES. 70

R. P. M. 151

SCALE 60

Area - 146

M.E.P. - 29.99

I.H.P. - 9.5

Thompson 1 1/2-inch Drum

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 33

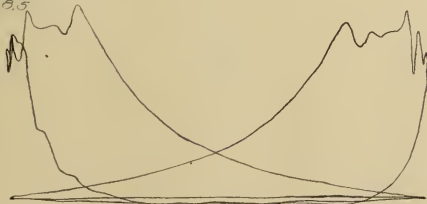
END

CYLINDER 10x10

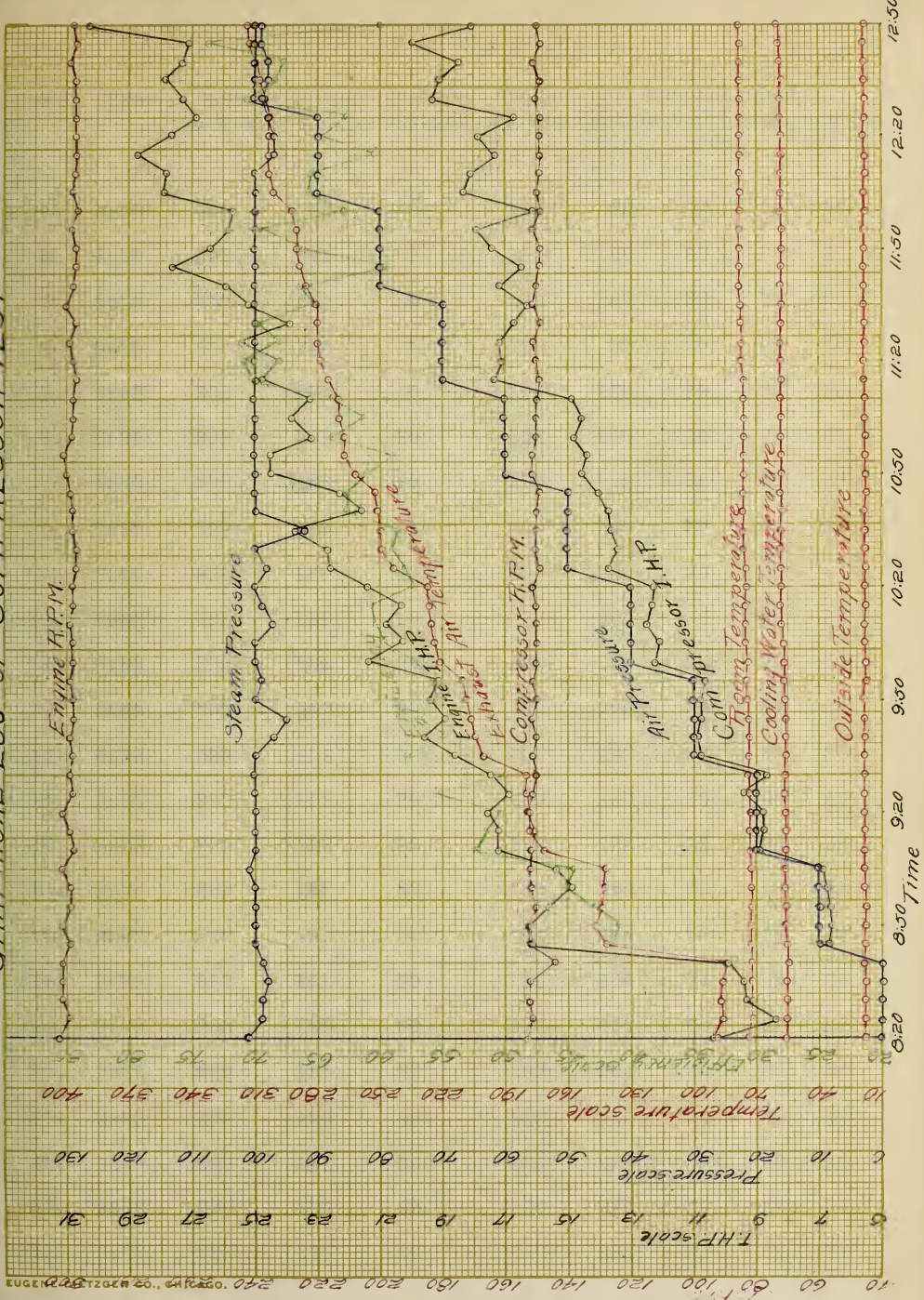
Area - 155

M.E.P. - 30.12

I.H.P. - 9.75



GRAPHICAL LOG OF COMPRESSOR TEST



No.	Time.	Engine	Comp.	Air	Steam	Temperatures.		
		R. P. M.	R. P. M.	Press.	Press.	Exhaust Air.	Out Room. Side.	Exhaust water.
1.	8:00	300	152	0	110	90	39	78
2.	8:05	299	152	0	108	88	39	77
3.	8:10	300	152	0	106	87	39	77
4.	8:15	300	152	0	108	85	39	77
5.	8:20	300	153	0	106	138	39	77
6.	8:25	298	151	10	105	140	38	78
7.	8:30	300	153	10	107	142	38	78
8.	8:35	300	153	10	110	140	37	79
9.	8:40	301	153	10	108	140	36	79
10.	8:45	301	152	10	110	140	36	79
11.	8:50	300	152	20	108	172	36	79
12.	8:55	300	152	20	105	178	36	79
13.	9:00	300	151	40	105	179	35	80
14.	9:05	300	151	20	108	180	35	80
15.	9:10	300	152	20	110	180	35	80
16.	9:15	299	151	30	110	198	35	80
17..	9:20	299	151	30	114	202	35	80
18.	9:25	299	151	30	113	204	34	80
19.	9:30	298	150	30	110	204	34	80
20.	9:35	299	151	30	107	204	34	80
21.	9:40	299	150	40	110	218	34	80
22.	9:45	299	151	40	110	220	34	80
23.	9:50	298	150	40	110	220	34	80
24.	9:55	298	151	40	110	224	33	80

Run	Time	Distance	Speed	Altitude	Temperature	Humidity	Wind	Clouds
1.	0:00	000	100	0	100	0	0	0
2.	0:00	000	100	0	100	0	0	0
3.	0:00	000	100	0	100	0	0	0
4.	0:00	000	100	0	100	0	0	0
5.	0:00	000	100	0	100	0	0	0
6.	0:00	000	100	0	100	0	0	0
7.	0:00	000	100	0	100	0	0	0
8.	0:00	000	100	0	100	0	0	0
9.	0:00	000	100	0	100	0	0	0
10.	0:00	000	100	0	100	0	0	0
11.	0:00	000	100	0	100	0	0	0
12.	0:00	000	100	0	100	0	0	0
13.	0:00	000	100	0	100	0	0	0
14.	0:00	000	100	0	100	0	0	0
15.	0:00	000	100	0	100	0	0	0
16.	0:00	000	100	0	100	0	0	0
17.	0:00	000	100	0	100	0	0	0
18.	0:00	000	100	0	100	0	0	0
19.	0:00	000	100	0	100	0	0	0
20.	0:00	000	100	0	100	0	0	0
21.	0:00	000	100	0	100	0	0	0
22.	0:00	000	100	0	100	0	0	0
23.	0:00	000	100	0	100	0	0	0
24.	0:00	000	100	0	100	0	0	0
25.	0:00	000	100	0	100	0	0	0
26.	0:00	000	100	0	100	0	0	0
27.	0:00	000	100	0	100	0	0	0
28.	0:00	000	100	0	100	0	0	0
29.	0:00	000	100	0	100	0	0	0
30.	0:00	000	100	0	100	0	0	0

No.	Time.	Engine R. P. M.	Compress. R. P. M.	Air Press.	Steam Press.	Temperatures.			
						Exhaust Air.	Out side.	Room.	Exhaust water
25.	10:00	298	150	40	110	224	33	81	57
26.	10:05	298	150	50	107	242	33	81	57
27.	10:10	299	150	50	112	245	32	81	57
28.	10:15	299	150	50	112	248	32	81	57
29.	10:20	299	151	50	113	249	32	81	57
30.	10:25	299	151	50	112	250	32	81	57
31.	10:30	298	150	60	114	267	32	81	57
32.	10:35	298	150	60	112	270	32	82	58
33.	10:40	298	149	60	112	270	32	82	58
34.	10:45	298	150	60	114	272	32	82	58
35.	10:50	299	150	60	115	272	32	82	58
36.	10:55	299	150	70	115	280	32	82	58
37.	11:00	298	149	70	111	282	32	82	58
38.	11:05	299	149	70	110	284	31	83	58
39.	11:10	298	149	70	108	284	31	83	58
40.	11:15	298	149	70	105	284	30	83	58
41.	11:20	298	150	80	105	288	30	83	58
42.	11:25	298	150	80	113	292	30	83	59
43.	11:30	298	150	80	114	293	30	83	59
44.	11:35	298	150	80	112	293	30	83	59
45.	11:40	298	150	80	113	294	30	83	59
46.	11:45	299	150	90	113	298	30	83	59
47.	11:50	299	150	90	112	300	29	83	59
48.	11:55	299	150	90	112	302	29	83	60

No.	Time.	Engine	Compress.	Air	Steam	Temperatures.			
		R.P.M.	R.P.M.	Press.	Press.	Exhaust Air.	Out side.	Room.	Exhaust water.
49.	12:00	299	150	90	110	302	28	83	60
50.	12:05	299	150	90	110	304	28	83	60
51.	12:10	299	151	100	114	310	28	83	60
52.	12:15	299	150	100	113	312	28	83	60
53.	12:20	299	150	100	114	314	28	83	60
54.	12:25	299	150	100	114	314	28	83	60
55.	12:30	299	150	100	112	314	28	83	60

Time	Lat.	Long.	Alt.	Dist.	Time	Lat.	Long.	Alt.	Dist.
12:00	30.00	120.00	100	100	12:00	30.00	120.00	100	100
12:05	30.00	120.00	100	100	12:05	30.00	120.00	100	100
12:10	30.00	120.00	100	100	12:10	30.00	120.00	100	100
12:15	30.00	120.00	100	100	12:15	30.00	120.00	100	100
12:20	30.00	120.00	100	100	12:20	30.00	120.00	100	100
12:25	30.00	120.00	100	100	12:25	30.00	120.00	100	100
12:30	30.00	120.00	100	100	12:30	30.00	120.00	100	100

No.	Time.	Engine I. H. P.	Compress. I. H. P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per. sq. in.
1.	8:00	7.10				0
2.	8:05	7.44				0
3.	8:10	6.69				0
4.	8:15	7.68				0
5.	8:20	7.34				0
6.	8:25	12.25	6.66	54.4		10
7.	8:30	10.81	6.75	62.5		10
8.	8:35	12.48	6.56	52.5	56.38	10
9.	8:40	12.23	6.89	56.3		10
10.	8:45	11.63	6.54	56.2		10
11.	8:50	16.34	9.72	59.4		20
12.	8:55	15.32	9.51	62.1		20
13.	9:00	14.53	9.56	65.8	61.54	20
14.	9:05	15.44	9.55	61.9		20
15.	9:10	16.21	9.64	59.5		20
16.	9:15	18.87	11.54	61.2		30
17.	9:20	19.13	11.69	61.2		30
18.	9:25	18.63	11.78	63.2	63.2	30
19.	9:30	18.01	11.69	64.9		30
20.	9:35	17.44	11.61	65.5		30
21.	9:40	20.80	13.38	64.4		40
22.	9:45	20.66	12.94	62.7		40
23.	9:50	20.46	13.44	65.7	65.2	40
24.	9:55	20.73	13.75	66.4		40

Time	Lat	Long	Alt	Temp	Wind	Dir
00	10 10	10 10	10 10	10 10	10 10	10 10
01	10 10	10 10	10 10	10 10	10 10	10 10
02	10 10	10 10	10 10	10 10	10 10	10 10
03	10 10	10 10	10 10	10 10	10 10	10 10
04	10 10	10 10	10 10	10 10	10 10	10 10
05	10 10	10 10	10 10	10 10	10 10	10 10
06	10 10	10 10	10 10	10 10	10 10	10 10
07	10 10	10 10	10 10	10 10	10 10	10 10
08	10 10	10 10	10 10	10 10	10 10	10 10
09	10 10	10 10	10 10	10 10	10 10	10 10
10	10 10	10 10	10 10	10 10	10 10	10 10
11	10 10	10 10	10 10	10 10	10 10	10 10
12	10 10	10 10	10 10	10 10	10 10	10 10
13	10 10	10 10	10 10	10 10	10 10	10 10
14	10 10	10 10	10 10	10 10	10 10	10 10
15	10 10	10 10	10 10	10 10	10 10	10 10
16	10 10	10 10	10 10	10 10	10 10	10 10
17	10 10	10 10	10 10	10 10	10 10	10 10
18	10 10	10 10	10 10	10 10	10 10	10 10
19	10 10	10 10	10 10	10 10	10 10	10 10
20	10 10	10 10	10 10	10 10	10 10	10 10
21	10 10	10 10	10 10	10 10	10 10	10 10
22	10 10	10 10	10 10	10 10	10 10	10 10
23	10 10	10 10	10 10	10 10	10 10	10 10
24	10 10	10 10	10 10	10 10	10 10	10 10

No.	Time.	Engine I.H.P.	Compress. I.H.P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per sq. in.
25.	10:00	20.46	13.66	66.8		40
26.	10:05	21.77	14.90	68.5		50
27.	10:10	21.78	14.16	65.1		50
28.	10:15	21.94	15.23	69.4	68.5	50
29.	10:20	21.94	15.20	69.2		50
30.	10:25	21.70	15.25	70.3		50
31.	10:30	23.17	17.18	74.1		60
32.	10:35	23.80	17.33	72.8		60
33.	10:40	23.13	17.13	74.0	72.4	60
34.	10:45	24.79	16.99	68.6		60
35.	10:50	23.62	17.13	72.5		60
36.	10:55	26.20	18.25	69.7		70
37.	11:00	24.68	18.14	73.5		70
38.	11:05	26.45	18.02	68.2	71.48	70
39.	11:10	25.63	18.02	70.3		70
40.	11:15	23.93	18.19	76.0		70
41.	11:20	26.11	19.28	73.8		80
42.	11:25	26.49	19.30	72.8		80
43.	11:30	27.13	19.22	70.8	72.74	80
44.	11:35	25.77	19.22	74.6		80
45.	11:40	27.01	19.37	71.7		80
46.	11:45	26.43	20.73	78.5		90
47.	11:50	27.44	20.58	75.0		90
48.	11:55	27.48	20.47	74.5	76.04	90

No.	Class.	Amount.	Debit.	Balance.	Notes.
10.	10:00	25.45	10.15	15.30	
11.	10:00	22.00	14.00	8.00	
12.	10:10	21.75	12.50	9.25	
13.	10:15	21.00	12.00	9.00	10.00
14.	10:20	21.85	12.50	9.35	
15.	10:25	21.50	12.00	9.50	
16.	10:30	21.75	12.15	9.60	
17.	10:35	22.00	12.50	9.50	
18.	10:40	22.15	12.15	10.00	10.00
19.	10:45	22.00	12.00	10.00	
20.	10:50	22.00	12.15	9.85	
21.	10:55	22.00	12.00	10.00	
22.	11:00	22.00	12.15	9.85	
23.	11:05	22.00	12.00	10.00	10.00
24.	11:10	22.00	12.00	10.00	
25.	11:15	22.00	12.15	9.85	
26.	11:20	22.00	12.00	10.00	
27.	11:25	22.00	12.00	10.00	10.00
28.	11:30	22.00	12.00	10.00	
29.	11:35	22.00	12.00	10.00	
30.	11:40	22.00	12.00	10.00	10.00
31.	11:45	22.00	12.00	10.00	
32.	11:50	22.00	12.00	10.00	
33.	11:55	22.00	12.00	10.00	10.00

No.	Time.	Engine I.H.P.	Compress. I.H.P.	Mech. Eff. %	Average Mech. Eff. %	Air Press. lbs. per. sq. in..
49.	12:00	26.25	20.41	77.8		90
50.	12:05	27.57	20.48	74.4		90
51.	12:10	28.45	21.85	76.8		100
52.	12:15	28.61	21.20	74.1		100
53.	12:20	28.23	21.11	74.8	76.1	100
54.	12:25	27.08	21.28	78.6		100
55.	12:30	27.84	21.23	76.2		100

W.	Time	Lat.	Long.	Alt.	Temp.	Wind
10	10:00	34.25	120.41	77.4		
11	11:00	34.30	120.40	77.5		
12	12:00	34.35	120.39	77.6		
13	13:00	34.40	120.38	77.7		
14	14:00	34.45	120.37	77.8		
15	15:00	34.50	120.36	77.9		
16	16:00	34.55	120.35	78.0		
17	17:00	35.00	120.34	78.1		
18	18:00	35.05	120.33	78.2		
19	19:00	35.10	120.32	78.3		
20	20:00	35.15	120.31	78.4		

10-2-00-2M-0

BOILER PRES. 110

R. P. M. 290

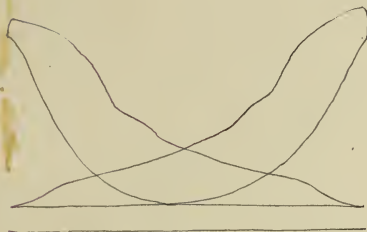
SCALE 60

Area = 1.06 sq"

M.E.P. = 23.39

I.H.P. = 13.85

Crosby 2-inch Drum



UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 59

END

CYLINDER 10x10

Area = 1.06 sq"

M.E.P. = 22.06

I.H.P. = 12.6

1-15-00-1M-0

BOILER PRES. 70

R. P. M. 140

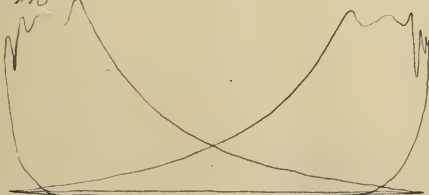
SCALE 60

Area = 1.6 sq"

M.E.P. = 31.03

I.H.P. = 21.5

Thompson 1 1/2-inch Drum



UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

CARD NO. 39

END

CYLINDER 10x10

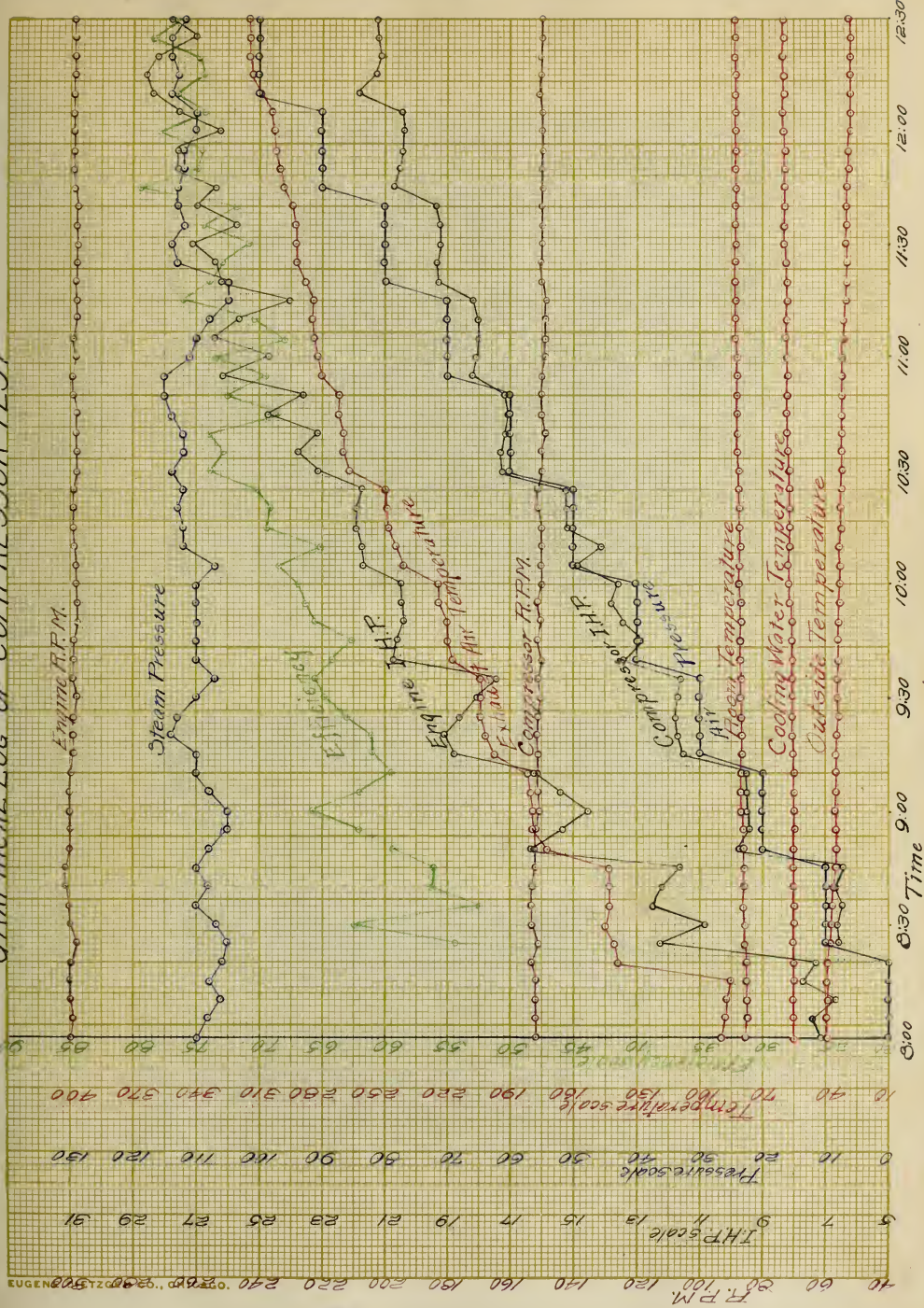
Area = 1.6 sq"

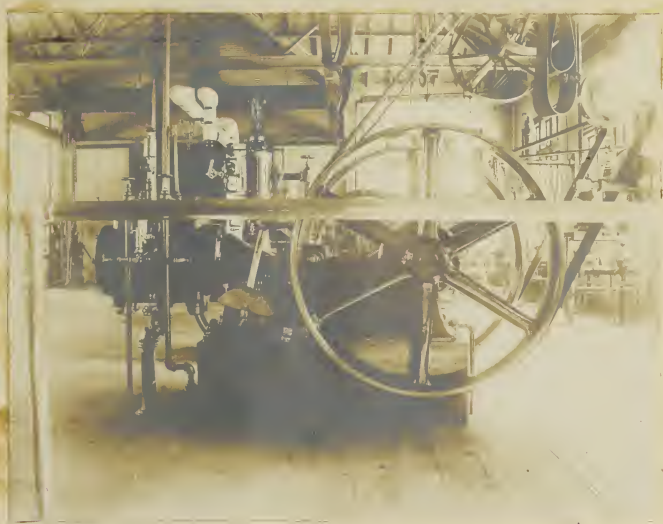
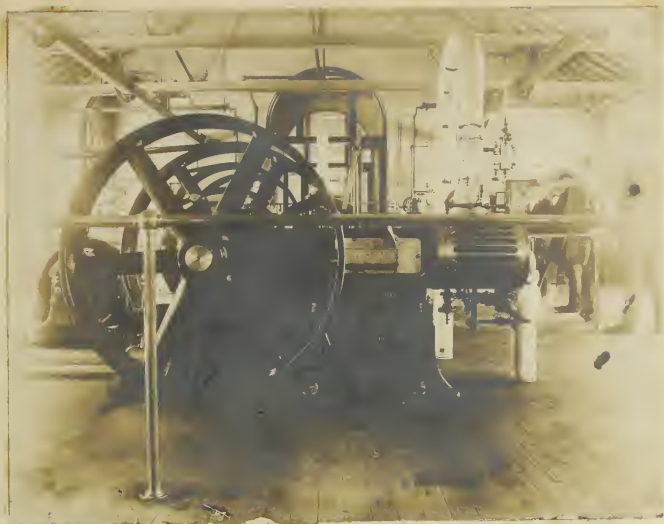
M.E.P. = 31.03

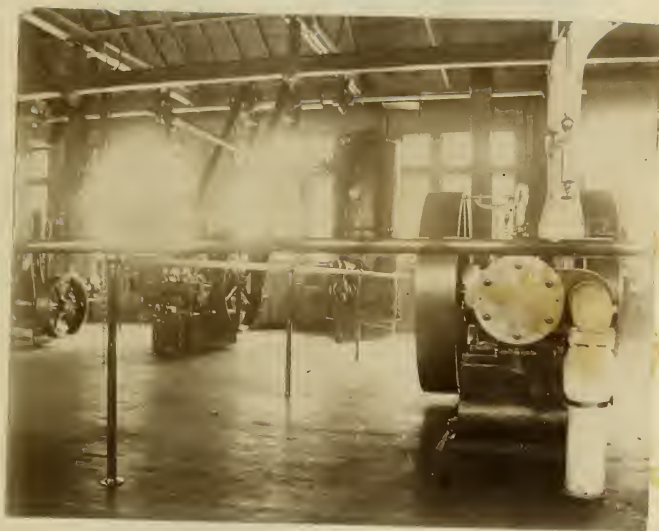
I.H.P. = 21.5



GRAPHICAL LOG OF COMPRESSOR TEST









Efficiency Test of Ingersoll-Sargent Duplex Compound Air Compressor
Class H, P. and E. shops, Urbana Illinois.

The object of this test was to determine the amount of power necessary to run the machine and also the efficiency with which the air compression was effected. The test was run while the machine was working under ordinary conditions. The machine supplies air for the entire shops. The test was run for three hours, from nine A.M. until twelve M. The readings and cards were taken simultaneously every five minutes. Revolutions were recorded every minute by means of a continuous counter.

The following readings were taken with each set of cards; time, steam-pressure, high air pressure, low air pressure, inlet air temperature, room temperature and R.P.M. The horse power developed by the various cylinders was found and then the mechanical efficiency was calculated.

Engine Constants.

$\frac{\text{PLAN}}{33000}$ H.P. $\frac{\text{L. A.}}{33000}$ constant.

Steam cylinders; Crank end $\frac{\text{LA}}{33000} = .0019039$, head end $\frac{\text{LA}}{33000} = .0019225$.

High pressure air, crank end $\frac{\text{LA}}{33000} = .0019225$, head end $\frac{\text{LA}}{33000} = .0019832$.

Low pressure air, crank end $\frac{\text{LA}}{33000} = .0050163$, head end, $\frac{\text{LA}}{33000} = .005077$.

The following are the original data and results:

No.	Time.	Steam	Air Pressure.		Temperatures.		R. P. M.
		Pressure.	High.	Low.	Inlet Air.	Room.	
1.	9:00	75	116	26	17	83	56
2.	9:05	75	115	26	17	83	55
3.	9:10	78	120	27	17	83	59
4.	9:15	76	120	27	18	83	44
5.	9:20	75	120	27	18	83	44
6.	9:25	75	110	25	19	84	56
7.	9:30	73	110	26	19	84	49
8.	9:35	72	105	26	19	84	50
9.	9:40	75	108	26	19	84	50
10.	9:45	77	115	26	19	85	47
11.	9:50	78	120	27	19	86	55
12.	9:55	78	125	27	19	86	49
13.	10:00	78	128	27	19	86	48
14.	10:05	75	130	27	19	86	43
15.	10:10	75	120	27	19	88	50
16.	10:15	75	125	27	19	88	52
17.	10:20	72	115	27	19	84	45
18.	10:25	73	118	27	19	82	49
19.	10:30	70	115	27	20	81	44
20.	10:35	72	112	27	20	81	55
21.	10:40	78	117	27	20	81	67
22.	10:45	75	120	27	20	79	47
23.	10:50	74	115	27	20	80	63
24.	10:55	75	125	27	20	79	51

Year	Month	Day	Hour	Minute	Second	Latitude	Longitude
1900	1	1	1	1	1	1	1
1900	1	2	1	1	1	1	1
1900	1	3	1	1	1	1	1
1900	1	4	1	1	1	1	1
1900	1	5	1	1	1	1	1
1900	1	6	1	1	1	1	1
1900	1	7	1	1	1	1	1
1900	1	8	1	1	1	1	1
1900	1	9	1	1	1	1	1
1900	1	10	1	1	1	1	1
1900	1	11	1	1	1	1	1
1900	1	12	1	1	1	1	1
1900	2	1	1	1	1	1	1
1900	2	2	1	1	1	1	1
1900	2	3	1	1	1	1	1
1900	2	4	1	1	1	1	1
1900	2	5	1	1	1	1	1
1900	2	6	1	1	1	1	1
1900	2	7	1	1	1	1	1
1900	2	8	1	1	1	1	1
1900	2	9	1	1	1	1	1
1900	2	10	1	1	1	1	1
1900	2	11	1	1	1	1	1
1900	2	12	1	1	1	1	1
1900	3	1	1	1	1	1	1
1900	3	2	1	1	1	1	1
1900	3	3	1	1	1	1	1
1900	3	4	1	1	1	1	1
1900	3	5	1	1	1	1	1
1900	3	6	1	1	1	1	1
1900	3	7	1	1	1	1	1
1900	3	8	1	1	1	1	1
1900	3	9	1	1	1	1	1
1900	3	10	1	1	1	1	1
1900	3	11	1	1	1	1	1
1900	3	12	1	1	1	1	1
1900	4	1	1	1	1	1	1
1900	4	2	1	1	1	1	1
1900	4	3	1	1	1	1	1
1900	4	4	1	1	1	1	1
1900	4	5	1	1	1	1	1
1900	4	6	1	1	1	1	1
1900	4	7	1	1	1	1	1
1900	4	8	1	1	1	1	1
1900	4	9	1	1	1	1	1
1900	4	10	1	1	1	1	1
1900	4	11	1	1	1	1	1
1900	4	12	1	1	1	1	1
1900	5	1	1	1	1	1	1
1900	5	2	1	1	1	1	1
1900	5	3	1	1	1	1	1
1900	5	4	1	1	1	1	1
1900	5	5	1	1	1	1	1
1900	5	6	1	1	1	1	1
1900	5	7	1	1	1	1	1
1900	5	8	1	1	1	1	1
1900	5	9	1	1	1	1	1
1900	5	10	1	1	1	1	1
1900	5	11	1	1	1	1	1
1900	5	12	1	1	1	1	1
1900	6	1	1	1	1	1	1
1900	6	2	1	1	1	1	1
1900	6	3	1	1	1	1	1
1900	6	4	1	1	1	1	1
1900	6	5	1	1	1	1	1
1900	6	6	1	1	1	1	1
1900	6	7	1	1	1	1	1
1900	6	8	1	1	1	1	1
1900	6	9	1	1	1	1	1
1900	6	10	1	1	1	1	1
1900	6	11	1	1	1	1	1
1900	6	12	1	1	1	1	1
1900	7	1	1	1	1	1	1
1900	7	2	1	1	1	1	1
1900	7	3	1	1	1	1	1
1900	7	4	1	1	1	1	1
1900	7	5	1	1	1	1	1
1900	7	6	1	1	1	1	1
1900	7	7	1	1	1	1	1
1900	7	8	1	1	1	1	1
1900	7	9	1	1	1	1	1
1900	7	10	1	1	1	1	1
1900	7	11	1	1	1	1	1
1900	7	12	1	1	1	1	1
1900	8	1	1	1	1	1	1
1900	8	2	1	1	1	1	1
1900	8	3	1	1	1	1	1
1900	8	4	1	1	1	1	1
1900	8	5	1	1	1	1	1
1900	8	6	1	1	1	1	1
1900	8	7	1	1	1	1	1
1900	8	8	1	1	1	1	1
1900	8	9	1	1	1	1	1
1900	8	10	1	1	1	1	1
1900	8	11	1	1	1	1	1
1900	8	12	1	1	1	1	1
1900	9	1	1	1	1	1	1
1900	9	2	1	1	1	1	1
1900	9	3	1	1	1	1	1
1900	9	4	1	1	1	1	1
1900	9	5	1	1	1	1	1
1900	9	6	1	1	1	1	1
1900	9	7	1	1	1	1	1
1900	9	8	1	1	1	1	1
1900	9	9	1	1	1	1	1
1900	9	10	1	1	1	1	1
1900	9	11	1	1	1	1	1
1900	9	12	1	1	1	1	1
1900	10	1	1	1	1	1	1
1900	10	2	1	1	1	1	1
1900	10	3	1	1	1	1	1
1900	10	4	1	1	1	1	1
1900	10	5	1	1	1	1	1
1900	10	6	1	1	1	1	1
1900	10	7	1	1	1	1	1
1900	10	8	1	1	1	1	1
1900	10	9	1	1	1	1	1
1900	10	10	1	1	1	1	1
1900	10	11	1	1	1	1	1
1900	10	12	1	1	1	1	1
1900	11	1	1	1	1	1	1
1900	11	2	1	1	1	1	1
1900	11	3	1	1	1	1	1
1900	11	4	1	1	1	1	1
1900	11	5	1	1	1	1	1
1900	11	6	1	1	1	1	1
1900	11	7	1	1	1	1	1
1900	11	8	1	1	1	1	1
1900	11	9	1	1	1	1	1
1900	11	10	1	1	1	1	1
1900	11	11	1	1	1	1	1
1900	11	12	1	1	1	1	1
1900	12	1	1	1	1	1	1
1900	12	2	1	1	1	1	1
1900	12	3	1	1	1	1	1
1900	12	4	1	1	1	1	1
1900	12	5	1	1	1	1	1
1900	12	6	1	1	1	1	1
1900	12	7	1	1	1	1	1
1900	12	8	1	1	1	1	1
1900	12	9	1	1	1	1	1
1900	12	10	1	1	1	1	1
1900	12	11	1	1	1	1	1
1900	12	12	1	1	1	1	1

No.	Time.	Steam	Air Pressure.		Temperatures.		R. P. M.
		Pressure.	High.	Low.	Inlet Air.	Room.	
25.	11:00	75	127	27	20	79	42
26.	11:05	81	130	27	21	81	60
27.	11:10	81	140	28	21	80	54
28.	11:15	76	132	27	21	79	45
29.	11:20	74	118	27	22.	76	51
30.	11:25	78	130	27	22.	78	54
31.	11:30	76	133	28	22	77	44
32.	11:35	78	135	28	22	80	46
33.	11:40	78	133	27	22	81	53
34.	11:45	72	125	28	24	80	41
35.	11:50	76	122	27	26	81	56
36.	11:55	76	130	27	28	82	50
37.	12:00	78	135	28	28	80	49

Time.	R. P. M.	Time.	R. P. M.	Time.	R. P. M.	Time.	R. P. M.
9:00	56	9:24	57	9:48	54	10:12	55
9:01	56	9:25	56	9:49	57	10:13	50
9:02	57	9:26	56	9:50	55	10:14	51
9:03	54	9:27	51	9:51	53	10:15	52
9:04	55	9:28	50	9:52	49	10:26	52
9:05	55	9:29	50	9:53	49	10:17	51
9:06	58	9:30	49	9:54	49	10:18	50
9:07	57	9:31	45	9:55	49	10:19	50
9:08	63	9:32	41	9:56	48	10:20	45
9:09	61	9:33	42	9:57	46	10:21	43
9:10	59	9:34	44	9:58	47	10:22	44
9:11	53	9:35	50	9:59	49	10:23	45
9:12	51	9:36	50	10:00	48	10:24	46
9:13	46	9:37	52	10:01	49	10:25	49
9:14	44	9:38	49	10:02	46	10:26	51
9:15	44	9:39	50	10:03	43	10:27	52
9:16	46	9:40	50	10:04	43	10:28	50
9:17	47	9:41	50	10:05	43	10:29	48
9:18	49	9:42	47	10:06	49	10:30	44
9:19	43	9:43	44	10:07	51	10:31	45
9:20	44	9:44	43	10:08	52	10:32	49
9:21	46	9:45	47	10:09	58	10:33	56
9:22	51	9:46	51	10:10	50	10:34	55
9:23	57	9:47	53	10:11	53	10:35	53

1990	1991	1992	1993	1994	1995	1996	1997
100	100.00	100	100.00	100	100.00	100	100.00
101	100.01	101	100.01	101	100.01	101	100.01
102	100.02	102	100.02	102	100.02	102	100.02
103	100.03	103	100.03	103	100.03	103	100.03
104	100.04	104	100.04	104	100.04	104	100.04
105	100.05	105	100.05	105	100.05	105	100.05
106	100.06	106	100.06	106	100.06	106	100.06
107	100.07	107	100.07	107	100.07	107	100.07
108	100.08	108	100.08	108	100.08	108	100.08
109	100.09	109	100.09	109	100.09	109	100.09
110	100.10	110	100.10	110	100.10	110	100.10
111	100.11	111	100.11	111	100.11	111	100.11
112	100.12	112	100.12	112	100.12	112	100.12
113	100.13	113	100.13	113	100.13	113	100.13
114	100.14	114	100.14	114	100.14	114	100.14
115	100.15	115	100.15	115	100.15	115	100.15
116	100.16	116	100.16	116	100.16	116	100.16
117	100.17	117	100.17	117	100.17	117	100.17
118	100.18	118	100.18	118	100.18	118	100.18
119	100.19	119	100.19	119	100.19	119	100.19
120	100.20	120	100.20	120	100.20	120	100.20
121	100.21	121	100.21	121	100.21	121	100.21
122	100.22	122	100.22	122	100.22	122	100.22
123	100.23	123	100.23	123	100.23	123	100.23
124	100.24	124	100.24	124	100.24	124	100.24
125	100.25	125	100.25	125	100.25	125	100.25
126	100.26	126	100.26	126	100.26	126	100.26
127	100.27	127	100.27	127	100.27	127	100.27
128	100.28	128	100.28	128	100.28	128	100.28
129	100.29	129	100.29	129	100.29	129	100.29
130	100.30	130	100.30	130	100.30	130	100.30
131	100.31	131	100.31	131	100.31	131	100.31
132	100.32	132	100.32	132	100.32	132	100.32
133	100.33	133	100.33	133	100.33	133	100.33
134	100.34	134	100.34	134	100.34	134	100.34
135	100.35	135	100.35	135	100.35	135	100.35
136	100.36	136	100.36	136	100.36	136	100.36
137	100.37	137	100.37	137	100.37	137	100.37
138	100.38	138	100.38	138	100.38	138	100.38
139	100.39	139	100.39	139	100.39	139	100.39
140	100.40	140	100.40	140	100.40	140	100.40

Time.	R. P. M.	Time.	R. P. M.	Time.	R. P. M.	Time.	R. P. M.
10:36	53	11:00	42	11:24	60	11:48	53
10:37	57	11:01	45	11:25	54	11:49	55
10:38	62	11:02	45	11:26	55	11:50	56
10:39	66	11:03	48	11:27	51	11:51	54
10:40	67	11:04	53	11:28	48	11:52	53
10:41	62	11:05	60	11:29	45	11:53	48
10:42	65	11:06	64	11:30	44	11:54	48
10:43	55	11:07	65	11:31	47	11:55	50
10:44	56	11:08	64	11:32	47	11:56	51
10:45	47	11:09	58	11:33	44	11:57	53
10:46	52	11:10	54	11:34	48	11:58	44
10:47	51	11:11	49	11:35	46	11:59	50
10:48	51	11:12	48	11:36	44	12:00	49
10:49	53	11:13	44	11:37	44		
10:50	63	11:14	43	11:38	48		
10:51	44	11:15	45	11:39	52		
10:52	52	11:16	51	11:40	53		
10:53	53	11:17	48	11:41	52		
10:54	52	11:18	50	11:42	51		
10:55	51	11:19	50	11:43	47		
10:56	48	11:20	51	11:44	42		
10:57	46	11:21	52	11:45	41		
10:58	42	11:22	53	11:46	45		
10:59	42	11:23	51	11:47	48		

Year	1967	1968	1969	1970	1971	1972	1973
1	1967	68	1968	69	1969	70	1970
2	1968	69	1969	70	1970	71	1971
3	1969	70	1970	71	1971	72	1972
4	1970	71	1971	72	1972	73	1973
5	1971	72	1972	73	1973	74	1974
6	1972	73	1973	74	1974	75	1975
7	1973	74	1974	75	1975	76	1976
8	1974	75	1975	76	1976	77	1977
9	1975	76	1976	77	1977	78	1978
10	1976	77	1977	78	1978	79	1979
11	1977	78	1978	79	1979	80	1980
12	1978	79	1979	80	1980	81	1981
13	1979	80	1980	81	1981	82	1982
14	1980	81	1981	82	1982	83	1983
15	1981	82	1982	83	1983	84	1984
16	1982	83	1983	84	1984	85	1985
17	1983	84	1984	85	1985	86	1986
18	1984	85	1985	86	1986	87	1987
19	1985	86	1986	87	1987	88	1988
20	1986	87	1987	88	1988	89	1989
21	1987	88	1988	89	1989	90	1990
22	1988	89	1989	90	1990	91	1991
23	1989	90	1990	91	1991	92	1992
24	1990	91	1991	92	1992	93	1993
25	1991	92	1992	93	1993	94	1994
26	1992	93	1993	94	1994	95	1995
27	1993	94	1994	95	1995	96	1996
28	1994	95	1995	96	1996	97	1997
29	1995	96	1996	97	1997	98	1998
30	1996	97	1997	98	1998	99	1999

No.	<u>I.H.P. Steam.</u>		Total I.H.P. Steam.	<u>I.H.P. Air</u>		Total I.H.P. Air.	Mech. Eff. %
	Low Side.	High Side.		Low Press.	High Press.		
1.	11.38	10.77	21.15	10.50	9.44	19.94	94.2
2.	11.22	10.62	21.84	10.24	9.50	19.74	90.3
3.	12.08	11.38	23.46	11.29	10.29	21.58	92.0
4.	8.80	8.23	17.03	8.22	7.36	15.58	91.4
5.	8.82	8.32	17.14	8.01	7.23	15.24	88.9
6.	10.94	10.42	21.36	10.29	9.24	19.53	91.4
7.	9.70	9.11	18.81	8.27	5.68	13.95	74.1
8.	9.59	9.01	18.60	9.11	7.55	16.66	89.2
9.	9.80	9.27	19.07	9.08	7.77	16.85	88.3
10.	9.42	9.00	18.42	8.64	7.71	16.35	88.7
11.	11.27	10.67	21.94	10.07	9.46	19.53	89.0
12.	10.32	9.65	19.97	10.42	8.76	19.18	96.0
13.	10.06	10.89	20.95	8.98	8.35	17.33	82.7
14.	8.91	8.48	17.39	7.79	7.38	15.17	87.2
15.	10.34	9.73	20.07	9.46	8.74	18.20	90.6
16.	10.72	11.28	22.00	10.91	9.25	20.16	91.6
17.	8.90	8.45	17.23	8.35	7.23	15.58	89.8
18.	9.89	9.44	19.33	9.27	8.35	17.62	90.0
19.	8.88	8.22	17.10	8.14	7.26	15.40	90.0
20.	11.27	10.67	21.94	10.37	8.98	19.35	88.2
21.	13.75	13.19	26.94	12.59	11.19	23.78	89.0
22.	9.83	9.27	19.10	8.84	8.05	16.89	88.4
23.	12.77	12.08	24.85	11.82	10.36	22.18	89.2
24.	10.78	10.20	20.98	10.64	8.96	19.60	93.4

No.	<u>I.H.P. Steam.</u>		Total I.H.P. Steam.	<u>I.H.P. Air.</u>		Total I.H.P. Air.	Mech. Eff. %
	Low Side.	High Side.		Low Press.	High Press.		
25.	8.99	8.44	17.43	7.96	7.55	15.51	88.9
26.	13.03	12.55	25.57	11.25	11.01	22.26	87.0
27.	12.13	11.25	23.38	10.25	10.19	20.24	87.4
28.	8.73	9.04	18.77	8.48	8.29	16.77	89.3
29.	10.37	9.84	20.21	8.37	8.68	18.05	89.3
30.	11.71	10.81	22.52	10.22	10.08	20.30	94.6
31.	9.53	8.99	18.52	8.44	8.25	16.69	90.1
32.	10.07	9.64	19.71	8.57	8.40	16.97	84.1
33.	11.56	10.82	11.38	11.24	10.05	21.29	95.1
34.	8.74	8.05	16.79	7.72	7.15	14.87	88.5
35.	11.95	11.01	22.96	10.50	9.93	20.43	88.9
36.	10.75	9.93	20.68	9.78	9.17	18.95	91.6
37."	10.41	10.09	20.50	9.17	9.19	18.36	89.5

Year	1900	1901	1902	1903	1904	1905	1906
1907	1908	1909	1910	1911	1912	1913	1914
1900	19.00	20.00	21.00	22.00	23.00	24.00	25.00
1901	25.00	26.00	27.00	28.00	29.00	30.00	31.00
1902	31.00	32.00	33.00	34.00	35.00	36.00	37.00
1903	37.00	38.00	39.00	40.00	41.00	42.00	43.00
1904	43.00	44.00	45.00	46.00	47.00	48.00	49.00
1905	49.00	50.00	51.00	52.00	53.00	54.00	55.00
1906	55.00	56.00	57.00	58.00	59.00	60.00	61.00
1907	61.00	62.00	63.00	64.00	65.00	66.00	67.00
1908	67.00	68.00	69.00	70.00	71.00	72.00	73.00
1909	73.00	74.00	75.00	76.00	77.00	78.00	79.00
1910	79.00	80.00	81.00	82.00	83.00	84.00	85.00
1911	85.00	86.00	87.00	88.00	89.00	90.00	91.00
1912	91.00	92.00	93.00	94.00	95.00	96.00	97.00
1913	97.00	98.00	99.00	100.00	101.00	102.00	103.00
1914	103.00	104.00	105.00	106.00	107.00	108.00	109.00
1915	109.00	110.00	111.00	112.00	113.00	114.00	115.00
1916	115.00	116.00	117.00	118.00	119.00	120.00	121.00
1917	121.00	122.00	123.00	124.00	125.00	126.00	127.00
1918	127.00	128.00	129.00	130.00	131.00	132.00	133.00
1919	133.00	134.00	135.00	136.00	137.00	138.00	139.00
1920	139.00	140.00	141.00	142.00	143.00	144.00	145.00
1921	145.00	146.00	147.00	148.00	149.00	150.00	151.00
1922	151.00	152.00	153.00	154.00	155.00	156.00	157.00
1923	157.00	158.00	159.00	160.00	161.00	162.00	163.00
1924	163.00	164.00	165.00	166.00	167.00	168.00	169.00
1925	169.00	170.00	171.00	172.00	173.00	174.00	175.00
1926	175.00	176.00	177.00	178.00	179.00	180.00	181.00
1927	181.00	182.00	183.00	184.00	185.00	186.00	187.00
1928	187.00	188.00	189.00	190.00	191.00	192.00	193.00
1929	193.00	194.00	195.00	196.00	197.00	198.00	199.00
1930	199.00	200.00	201.00	202.00	203.00	204.00	205.00
1931	205.00	206.00	207.00	208.00	209.00	210.00	211.00
1932	211.00	212.00	213.00	214.00	215.00	216.00	217.00
1933	217.00	218.00	219.00	220.00	221.00	222.00	223.00
1934	223.00	224.00	225.00	226.00	227.00	228.00	229.00
1935	229.00	230.00	231.00	232.00	233.00	234.00	235.00
1936	235.00	236.00	237.00	238.00	239.00	240.00	241.00
1937	241.00	242.00	243.00	244.00	245.00	246.00	247.00
1938	247.00	248.00	249.00	250.00	251.00	252.00	253.00
1939	253.00	254.00	255.00	256.00	257.00	258.00	259.00
1940	259.00	260.00	261.00	262.00	263.00	264.00	265.00
1941	265.00	266.00	267.00	268.00	269.00	270.00	271.00
1942	271.00	272.00	273.00	274.00	275.00	276.00	277.00
1943	277.00	278.00	279.00	280.00	281.00	282.00	283.00
1944	283.00	284.00	285.00	286.00	287.00	288.00	289.00
1945	289.00	290.00	291.00	292.00	293.00	294.00	295.00
1946	295.00	296.00	297.00	298.00	299.00	300.00	301.00
1947	301.00	302.00	303.00	304.00	305.00	306.00	307.00
1948	307.00	308.00	309.00	310.00	311.00	312.00	313.00
1949	313.00	314.00	315.00	316.00	317.00	318.00	319.00
1950	319.00	320.00	321.00	322.00	323.00	324.00	325.00
1951	325.00	326.00	327.00	328.00	329.00	330.00	331.00
1952	331.00	332.00	333.00	334.00	335.00	336.00	337.00
1953	337.00	338.00	339.00	340.00	341.00	342.00	343.00
1954	343.00	344.00	345.00	346.00	347.00	348.00	349.00
1955	349.00	350.00	351.00	352.00	353.00	354.00	355.00
1956	355.00	356.00	357.00	358.00	359.00	360.00	361.00
1957	361.00	362.00	363.00	364.00	365.00	366.00	367.00
1958	367.00	368.00	369.00	370.00	371.00	372.00	373.00
1959	373.00	374.00	375.00	376.00	377.00	378.00	379.00
1960	379.00	380.00	381.00	382.00	383.00	384.00	385.00
1961	385.00	386.00	387.00	388.00	389.00	390.00	391.00
1962	391.00	392.00	393.00	394.00	395.00	396.00	397.00
1963	397.00	398.00	399.00	400.00	401.00	402.00	403.00
1964	403.00	404.00	405.00	406.00	407.00	408.00	409.00
1965	409.00	410.00	411.00	412.00	413.00	414.00	415.00
1966	415.00	416.00	417.00	418.00	419.00	420.00	421.00
1967	421.00	422.00	423.00	424.00	425.00	426.00	427.00
1968	427.00	428.00	429.00	430.00	431.00	432.00	433.00
1969	433.00	434.00	435.00	436.00	437.00	438.00	439.00
1970	439.00	440.00	441.00	442.00	443.00	444.00	445.00
1971	445.00	446.00	447.00	448.00	449.00	450.00	451.00
1972	451.00	452.00	453.00	454.00	455.00	456.00	457.00
1973	457.00	458.00	459.00	460.00	461.00	462.00	463.00
1974	463.00	464.00	465.00	466.00	467.00	468.00	469.00
1975	469.00	470.00	471.00	472.00	473.00	474.00	475.00
1976	475.00	476.00	477.00	478.00	479.00	480.00	481.00
1977	481.00	482.00	483.00	484.00	485.00	486.00	487.00
1978	487.00	488.00	489.00	490.00	491.00	492.00	493.00
1979	493.00	494.00	495.00	496.00	497.00	498.00	499.00
1980	499.00	500.00	501.00	502.00	503.00	504.00	505.00
1981	505.00	506.00	507.00	508.00	509.00	510.00	511.00
1982	511.00	512.00	513.00	514.00	515.00	516.00	517.00
1983	517.00	518.00	519.00	520.00	521.00	522.00	523.00
1984	523.00	524.00	525.00	526.00	527.00	528.00	529.00
1985	529.00	530.00	531.00	532.00	533.00	534.00	535.00
1986	535.00	536.00	537.00	538.00	539.00	540.00	541.00
1987	541.00	542.00	543.00	544.00	545.00	546.00	547.00
1988	547.00	548.00	549.00	550.00	551.00	552.00	553.00
1989	553.00	554.00	555.00	556.00	557.00	558.00	559.00
1990	559.00	560.00	561.00	562.00	563.00	564.00	565.00
1991	565.00	566.00	567.00	568.00	569.00	570.00	571.00
1992	571.00	572.00	573.00	574.00	575.00	576.00	577.00
1993	577.00	578.00	579.00	580.00	581.00	582.00	583.00
1994	583.00	584.00	585.00	586.00	587.00	588.00	589.00
1995	589.00	590.00	591.00	592.00	593.00	594.00	595.00
1996	595.00	596.00	597.00	598.00	599.00	600.00	601.00
1997	601.00	602.00	603.00	604.00	605.00	606.00	607.00
1998	607.00	608.00	609.00	610.00	611.00	612.00	613.00
1999	613.00	614.00	615.00	616.00	617.00	618.00	619.00
2000	619.00	620.00	621.00	622.00	623.00	624.00	625.00
2001	625.00	626.00	627.00	628.00	629.00	630.00	631.00
2002	631.00	632.00	633.00	634.00	635.00	636.00	637.00
2003	637.00	638.00	639.00	640.00	641.00	642.00	643.00
2004	643.00	644.00	645.00	646.00	647.00	648.00	649.00
2005	649.00	650.00	651.00	652.00	653.00	654.00	655.00
2006	655.00	656.00	657.00	658.00	659.00	660.00	661.00
2007	661.00	662.00	663.00	664.00	665.00	666.00	667.00
2008	667.00	668.00	669.00	670.00	671.00	672.00	673.00
2009	673.00	674.00	675.00	676.00	677.00	678.00	679.00
2010	679.00	680.00	681.00	682.00	683.00	684.00	685.00
2011	685.00	686.00	687.00	688.00	689.00	690.00	691.00
2012	691.00	692.00	693.00	694.00	695.00	696.00	697.00
2013	697.00	698.00	699.00	700.00	701.00	702.00	703.00
2014	703.00	704.00	705.00	706.00	707.00	708.00	709.00
2015	709.00	710.00	711.00	712.00	713.00	714.00	715.00
2016	715.00	716.00	717.00	718.00	719.00	720.00	721.00
2017	721.00	722.00	723.00	724.00	725.00	726.00	727.00
2018	727.00	728.00	729.00	730.00	731.00	732.00	733.00
2019	733.00	734.00	735.00	736.00	737.00	738.00	739.00
2020	739.00	740.00	741.00	742.00	743.00	744.00	745.00
2021	745.00	746.00	747.00	748.00	749.00	750.00	751.00
2022	751.00	752.00	753.00	754.00	755.00	756.00	757.00
2023	757.00	758.00	759.00	760.00	761.00	762.00	763.00
2024	763.00	764.00	765.00	766.00	767.00	768.00	769.00
2025	769.00	770.00	771.00	772.00	773.00	774.00	775.00
2026	775.00	776.00	777.00	778.00	779.00	780.00	781.00
2027	781.00	782.00	783.00	784.00	785.00	786.00	787.00
2028	787.00	788.00	789.00	790.00	791.00	792.00	793.00
2029	793.00	794.00	795.00	796.00	797.00	798.00	799.00
2030	799.00	800.00	801.00	802.00	803.00	804.00	805.00
2031	805.00	806.00	807.00	808.00	809.00	810.00	811.00
2032	811.00	812.00	813.00	814.00	815.00	816.00	817.00
2033	817.00	818.00	819.00	820.00	821		

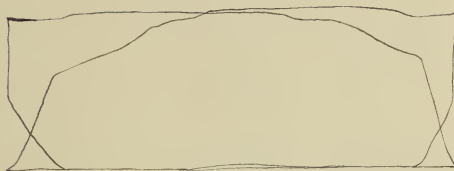
10-240-2M-0

BOILER PRES. 72R. P. M. 45SCALE 50Area = 3.34 sq"M.E.P. = 50.60I.H.P. = 4.07UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORYCARD NO. 17

END

CYLINDER 10X10Area = 3.15 sq"M.E.P. = 47.72I.H.P. = 4.02

Crosby 2-Inch Drum



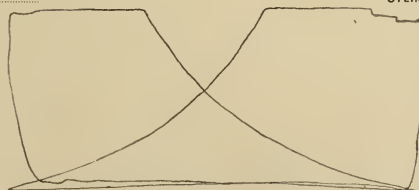
1-15-40-1M-0

BOILER PRES. 115R. P. M. 45SCALE 60Area = 0M.E.P. = 39.61I.H.P. = 3.49UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORYCARD NO. 15

END

CYLINDER 10X10Area = 2.81 sq"M.E.P. = 40.38I.H.P. = 3.74

Thompson 1 1/2-Inch Drum



10-200-2M-0

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

BOILER PRES. 70R. P. M. 45SCALE 30

Area = 3.45

M.E.P. = 51.71

I.H.P. = 4.47

CARD NO. 16

END

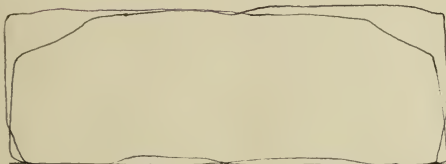
CYLINDER 10x10

Area = 3.45

M.E.P. = 51.71

I.H.P. = 4.47

Crosby 2-inch Drum



10-200-2M-0

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING LABORATORY

BOILER PRES. 27R. P. M. 45SCALE 30

Area = 1.39

M.E.P. = 17.33

I.H.P. = 4.03

CARD NO. 17

END

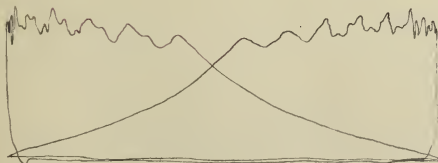
CYLINDER 10x16

Area = 2.0 "2"

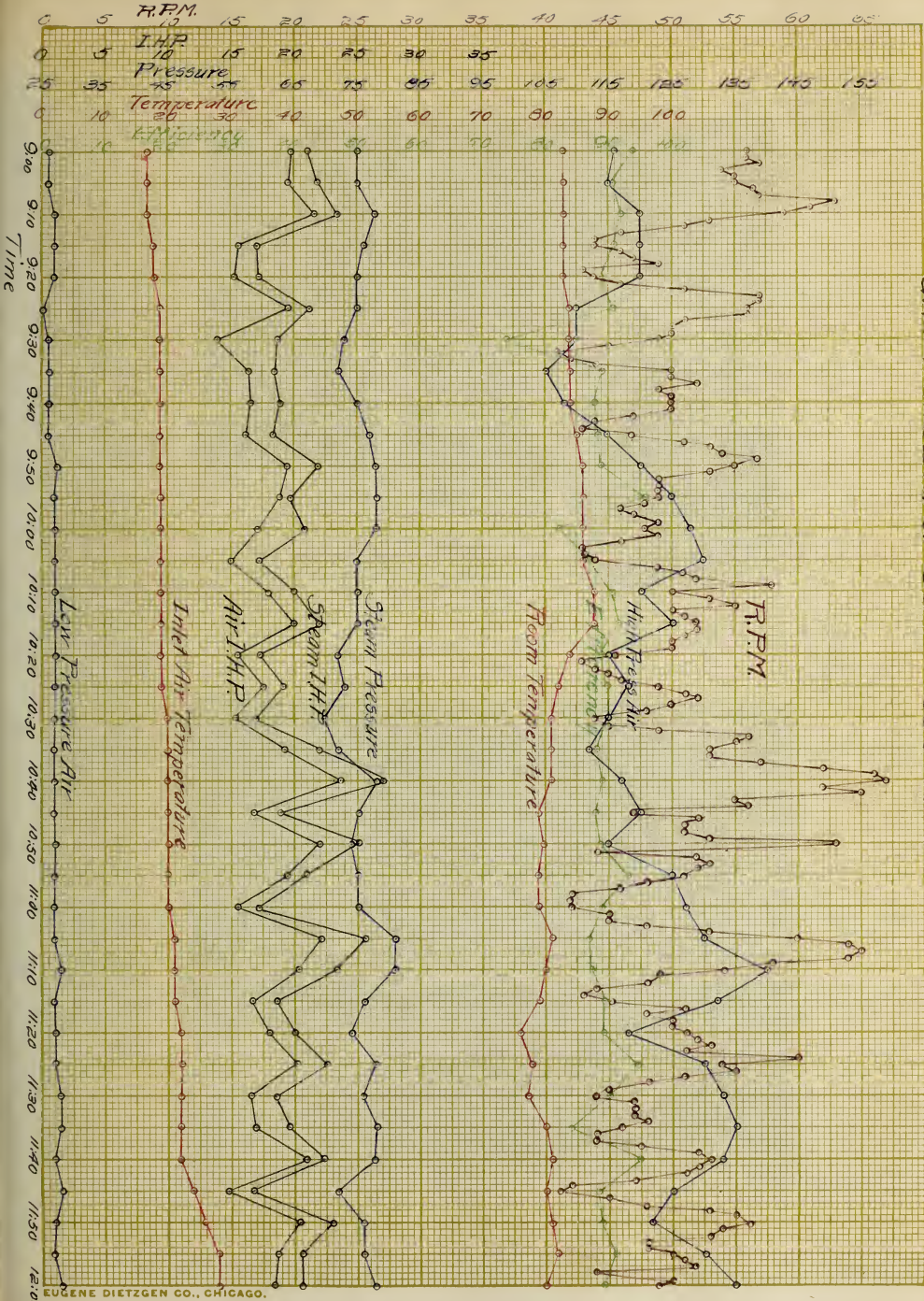
M.E.P. = 17.33

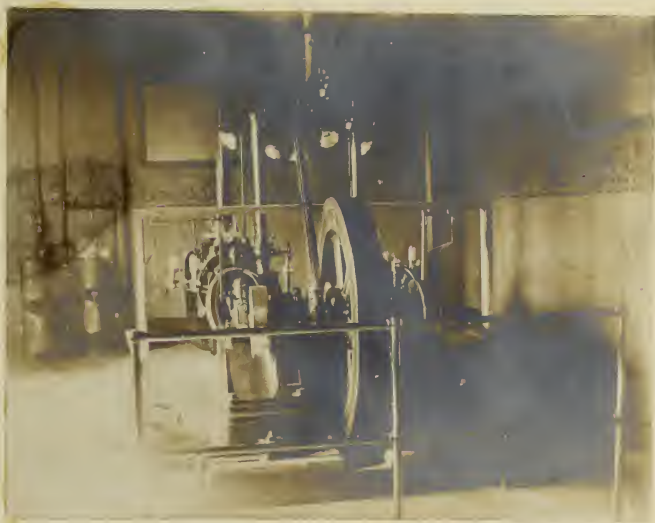
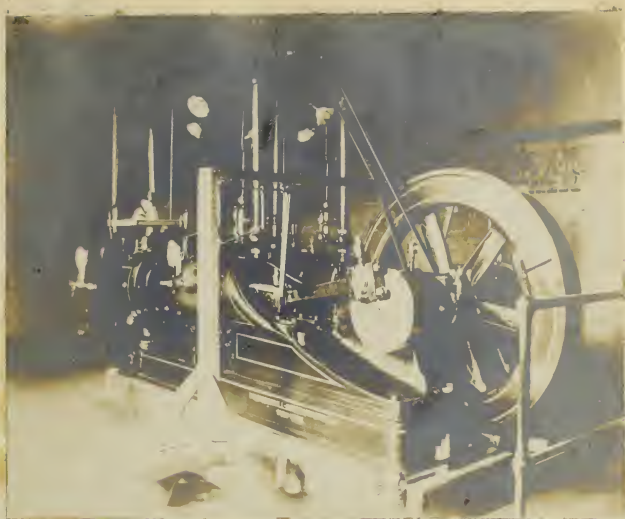
I.H.P. = 4.27

Crosby 2-inch Drum



GRAPHICAL LOG OF COMPRESSOR TEST





Test of a Compound Marine Steam Engine Run by Compressed Air.

The object of the test was to determine the amount of air consumed per. brake-horse-power-hour using air at different pressures and running the engine at different speeds. Also to find the value of heating the air.

The engine used was the 2 3/8" x 4 1/4" x 3 1/8" Marine Engine in the Mechanical Engineering Laboratory at the University of Ill.

To accomplish this object, tests of one hour duration were run at constant pressure and brake load; the revolutions of the engine and brake load were recorded, also the amount of air used during the test, which was found by keeping track of the compressor, by continuous counter and multiplying the number of revolutions of compressor during the test by the weight of air compressed per stroke, the pressure in the tank being brought to the same point as at the beginning of the test.

The amount of air compressed per revolution of compressor was found as follows: The receiver was carefully calibrated as to volume by filling it with water at the top of the tank until full and then let run out at the bottom and carefully weighed. This being repeated several times to insure accuracy.

The volume of the pipe from the compressor to tank and from the tank to engine was calculated and added to the calibrated volume of the tank. The total volume was found to be 90.447 cubic feet.

Thermometers were inserted in the side of the tank to get the temperature near the top and bottom and the average was used. The

The object of this journal is to provide a medium for the publication of original researches, clinical reports, and other material of interest to the medical profession. It is published weekly, except during the months of December and January, when it is published bi-weekly.

The journal is published by the American Medical Association, 535 North Dearborn Street, Chicago, Ill. 60610. The subscription price for 1919 is \$5.00 in advance. Single copies are sold at 15 cents. The journal is sent free of charge to members of the American Medical Association. The journal is also sent free of charge to libraries and other institutions. The journal is indexed and abstracted in the following publications: Index Medicus, Current Contents, and others.

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continuous counter was placed on the compressor to get the total number of revolutions.

The tank being empty the compressor was started and ^{the} number of revolutions required to pump the air in the tank from 0 pounds to 100 pounds noted also the average temperature of the air in the tank at 0 pounds and 100 pounds.

From this the weight of free air pumped in was calculated by means of the formula $G-G' = V/R (p/T-p'/T')$ in which G = weight of air, p = absolute pressure and T = absolute temperature at 100 pounds gauge pressure and G', p', T' , denote the same at 0 pounds gauge pressure. $G-G'$ = weight of air pumped into the tank which divided by the total number of revolutions of the compressor equals the amount of free air in pounds compressed per. revolution.

To find the brake horse-power of the engine multiply the perimeter of the circle having the length of the brake arm, which is 2 1/6 feet by the number of revolutions of the engine and by the weight on scale less weight of brake arm and divide this product by 33000.

Dividing the horse power of the engine by the weight of air used per. hour we have the air consumption in pounds per. brake-horse-power-hour. To find the cubic feet at 60 degrees F. multiply the number of pounds by 12.61.

To find the result of reheating compare the results of tests with the same initial pressure at engine and same number of revolutions of the engine.

To get pressure and temperature before entering the engine a pressure gauge and thermometer were inserted between the throttle

Department of Agriculture

The following report was submitted to the

Department of Agriculture for the year ending June 30, 1911, by the

Director of the Bureau of Plant Industry

It will be noted that the report for the year ending June 30, 1911, is

the same as the report for the year ending June 30, 1910, and that the

report for the year ending June 30, 1911, is the same as the report for

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valve and the engine. A thermometer was also inserted in the pipe between ^{the} high and low pressure cylinders to get ^{the} temperature of the air, also one in the exhaust pipe.

Tests were run at 50, 65 and 80 pounds initial pressure, regulated by a hand governed throttle valve, with engine running at 200, 300 and 400 R.P.M. each. The temperature of air was noted in each test before entering, between cylinders and in the exhaust pipe.

Tests were run using cold air, air heated before entering engine and before entering and between cylinders.

The air was heated between cylinders by means of a gas flame under a long pipe which was inserted in place of the short connection originally there.

The following sheets contain tabulated results and value of reheating, also photographs to show arrangement of brake and reheating connections.

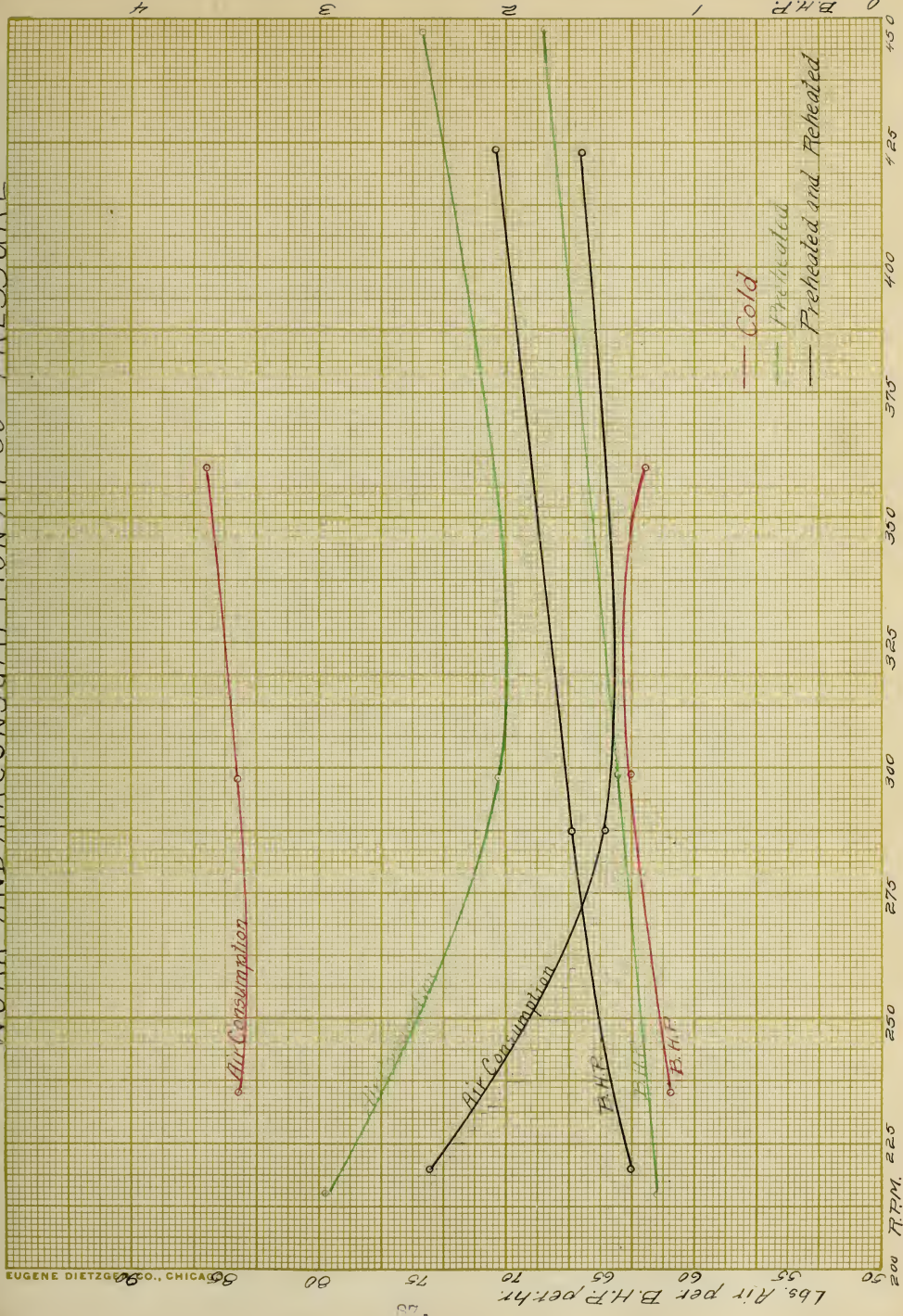
No.	Time. hrs.	R.P.M.	Press.	Load.	Temperatures		B.H.P.	Total air used.	Air per. B.H.P. per. hour.	
					Before enter- ing.	Between cylin- ders.			Lbs.	Cu.Ft.
1.	1	360	50	9	81		30	1.28 110.62	85.6	1079.4
2.	1	297	50	11	82		25	1.34 112.92	84.2	1065.7
3.	1	234	50	12	81		30	1.15 97.06	84.4	1064.2
4.	1	381	65	11.5	82		12	1.80 160.0	88.8	1119.7
5.	1	325	65	13	82		10	1.69 142.6	84.3	1062.0
6.	1	272	65	14	82		12	1.48 126.6	85.5	1078.1
7.	1	372	80	16	82		0	2.32 199.0	85.8	1081.9
8.	1	344	80	18	82		0	2.55 198.77	77.8	981.0
9.	1	284	80	19.5	82		-2	2.28 183.38	80.4	1013.8
10.	1	446	50	10	205		57	1.83 135.03	74.5	939.4
11.	1	296	50	12	230		62	1.43 103.91	70.3	886.4
12.	1	216	50	13.3	230		54	1.18 94.25	79.8	1006.2
13.	1	434	65	14	200		30	2.51 168.43	67.1	846.1
14.	1	275	65	17	215		45	1.81 119.91	56.1	833.5
15.	1	203	65	18.8	210		45	1.57 111.47	71.0	895.3
16.	1	398.	80	18	173		40	2.95 191.75	65.0	819.6
17.	1	307	80	21.3	190		30	2.69 175.4	64.0	807.0
18.	1	238	80	23	200		30	2.28 157.8	69.1	871.3
19.	1	421	50	12	175	255	110	2.08 137.98	66.0	832.2
20.	1	288	50	14	215	255	115	1.66 107.38	64.6	814.6
21.	1	217	50	15	212	250	105	1.34 99.94	74.0	933.1
22.	1	398	65	16	175	208	75	2.62 162.44	62.0	781.8
23.	1	329	65	17.5	197	247	95	2.38 138.04	58.0	731.3
24.	1	219	65	20	220	250	105	1.80 117.04	65.0	819.6

No.	Time. hrs.	R. P. M.	Press.	Load.	Temperatures.			B. H. P. Total.		Air per.	
					Before	Between	Ex-	air used.	B. H. P.	per. hour.	lbs. cu. ft.
					enter- ing.	cylin- ders.	haust. ing.				
25.	1	400	80	20.5	165	190	65	3.68	207.2	56.5	712.4
26.	1	295	80	23	177	217	70	2.76	165.6	58.0	731.3
27.	1	211	80	26	188	245	87	2.26	145.2	64.2	809.5

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WORK AND AIR CONSUMPTION AT 50th PRESSURE



WORK AND AIR CONSUMPTION AT 65 # PRESSURE

EUGENE DIETZGEN CO., CHICAGO

55

Lbs Air per B.H.P. per hr

50

55

60

65

70

75

80

85

90

95

100

200

225

250

275

300

325

350

375

400

425

450

Cold

Preheated

Preheated and Reheated

Air Consumption

B.H.P.

B.H.P.

Air Consumption

B.H.P.

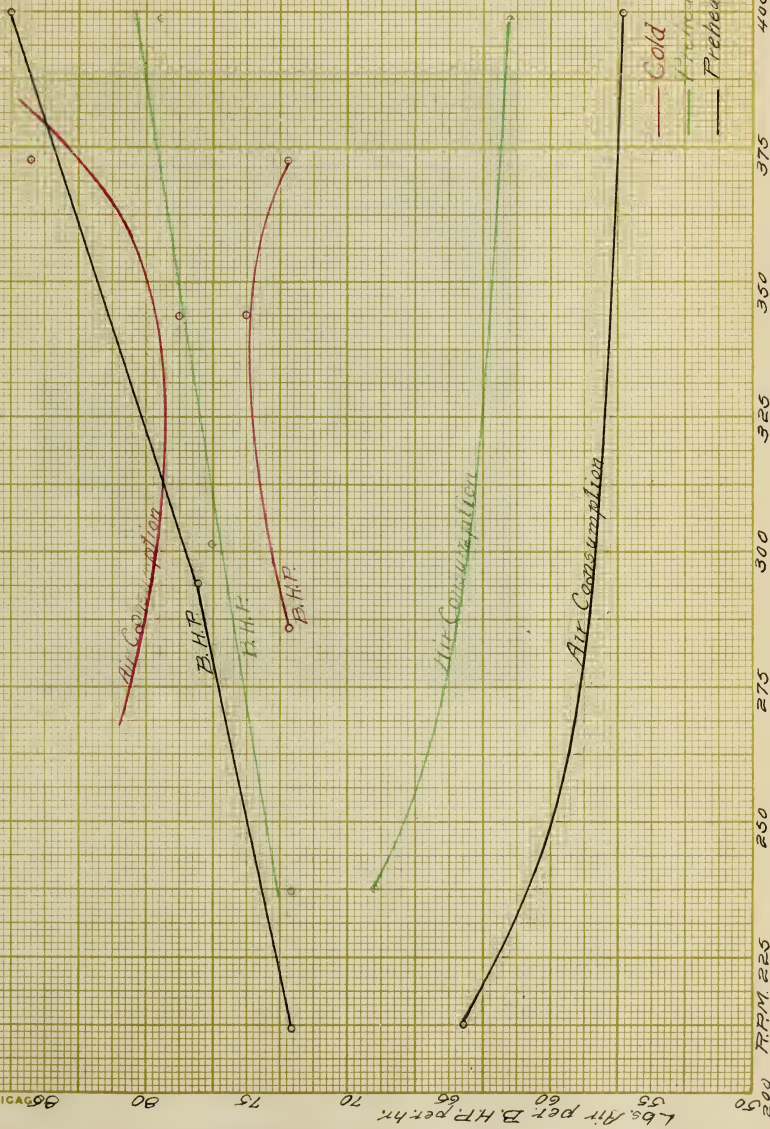
Air Consumption

Preheated

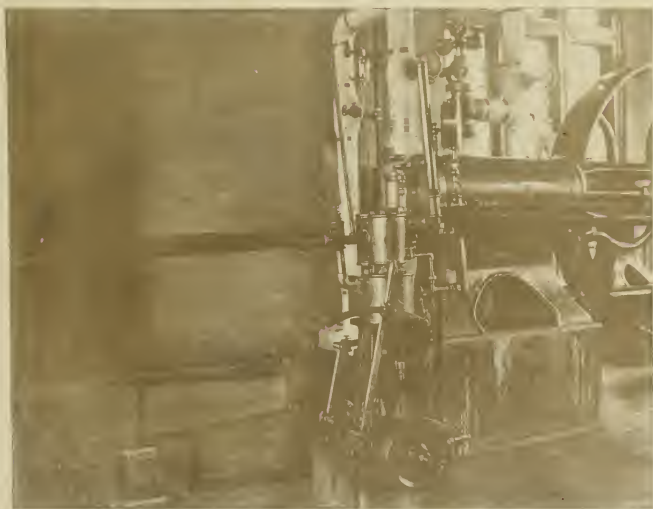
Preheated and Reheated

WORK AND AIR CONSUMPTION AT 80# PRESSURE

EUGENE DIETZGEN CO., CHICAGO, ILL.









Tests on an Oscillating Steam Engine Run by Compressed Air.

The object of the test was to find the amount of air consumed per. brake horse power per. hour using air at different pressures and running the engine with different brake loads from zero to a maximum. Also to find the value of heating the air.

The engine used in these tests was the oscillating engine used to run the Babcock and Wilcox chain grate at the University of Illinois heating and boiler plant.

The engine was removed from its foundation, taken into the testing laboratory and connected up with air as shown in the accompanying photograph.

Owing to the limits of time tests of fifteen minutes duration were run with air at 65 pounds and 80 pounds pressures and brake loads of 0, 2, 4, 6, 8, 10, 12, and 14 pounds using air cold; then the tests were repeated using air heated.

The air consumption was obtained in the same way as in the previous test.

The following pages show the data and results of the tests.

The object of this study was to determine the effect of the various factors which enter into the production of the various types of pneumonia. The results of the study are as follows: 1. The various types of pneumonia are produced by different organisms. 2. The various types of pneumonia are produced by different organisms. 3. The various types of pneumonia are produced by different organisms.

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No.	Time. mins.	R.P.M.	Press.	Load.	Temperatures.		B.H.P.	Total. air used.	Air per. B.H.P. hr.	
					Before.	Exhaust.			Lbs.	Cu. Ft.
1.	15	330	65	0	89	72	.0	14.96		
2.	15	280	65	2	89	62	.23	15.02	260.	3276
3.	15	250	65	4	90	55	.41	18.20	172.8	2177
4.	15	243	65	6	90	50	.59	22.79	152.4	1920
5.	15	230	65	8	89	42	.75	31.33	160.8	2026
6.	15	222	65	10	90	38	.91	36.91	161.2	2031
7.	15	204	65	12	91	40	1.00	45.42	180.0	2268
8.	15	249	80	4	96	40	.41	20.05	195.2	2459
9.	15	246	80	6	96	34	.60	24.55	161.2	2031
10.	15	245	80	8	90	25	.80	28.46	140.8	1774
11.	15	232	80	10	90	27	.95	44.50	186.4	2348
12.	15	221	80	12	91	32	1.09	58.92	215.2	2711
13.	15	157	80	14	96	45	.89	77.50	348.4	4389
14.	15	365	65	0	200	94	.0	13.03		
15.	15	269	65	2	200	93	.22	13.34	241.2	3039
16.	15	254	65	4	200	88	.42	16.00	153.6	1934
17.	15	242	65	6	200	76	.59	17.89	119.6	1506
18.	15	239	65	8	200	74	.83	24.51	118.0	1486
19.	15	230	55	10	190	72	.94	31.94	134.6	1695
20.	15	203	65	12	165	70	1.00	44.00	175.2	2207
21.	15	255	80	4	200	97	.42	18.53	176.4	2222
22.	15	247	80	6	200	86	.61	23.03	150.4	1895
23.	15	242	80	8	200	76	.80	28.29	140.0	1764
24.	15	235	80	10	195	78	.96	38.93	160.4	2021

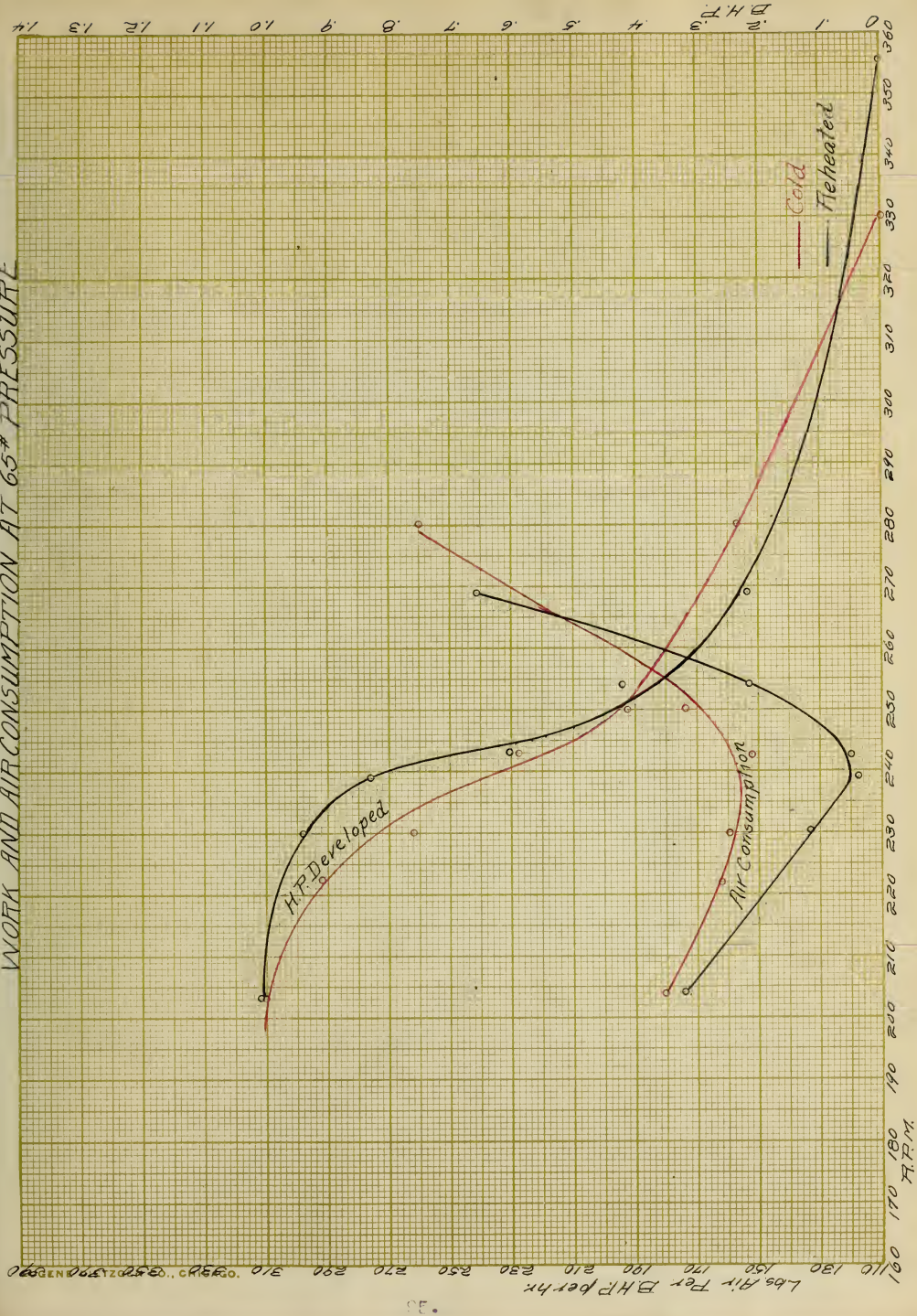
Date		Description						Total	
Year	Month	Day	Particulars	Debit	Credit	Balance	Interest	Amount	Rate
1900	Jan	1	Balance			100.00		100.00	
1900	Jan	2	Interest	1.00		99.00		1.00	1%
1900	Jan	3	Interest	1.00		98.00		2.00	1%
1900	Jan	4	Interest	1.00		97.00		3.00	1%
1900	Jan	5	Interest	1.00		96.00		4.00	1%
1900	Jan	6	Interest	1.00		95.00		5.00	1%
1900	Jan	7	Interest	1.00		94.00		6.00	1%
1900	Jan	8	Interest	1.00		93.00		7.00	1%
1900	Jan	9	Interest	1.00		92.00		8.00	1%
1900	Jan	10	Interest	1.00		91.00		9.00	1%
1900	Jan	11	Interest	1.00		90.00		10.00	1%
1900	Jan	12	Interest	1.00		89.00		11.00	1%
1900	Jan	13	Interest	1.00		88.00		12.00	1%
1900	Jan	14	Interest	1.00		87.00		13.00	1%
1900	Jan	15	Interest	1.00		86.00		14.00	1%
1900	Jan	16	Interest	1.00		85.00		15.00	1%
1900	Jan	17	Interest	1.00		84.00		16.00	1%
1900	Jan	18	Interest	1.00		83.00		17.00	1%
1900	Jan	19	Interest	1.00		82.00		18.00	1%
1900	Jan	20	Interest	1.00		81.00		19.00	1%
1900	Jan	21	Interest	1.00		80.00		20.00	1%
1900	Jan	22	Interest	1.00		79.00		21.00	1%
1900	Jan	23	Interest	1.00		78.00		22.00	1%
1900	Jan	24	Interest	1.00		77.00		23.00	1%
1900	Jan	25	Interest	1.00		76.00		24.00	1%
1900	Jan	26	Interest	1.00		75.00		25.00	1%
1900	Jan	27	Interest	1.00		74.00		26.00	1%
1900	Jan	28	Interest	1.00		73.00		27.00	1%
1900	Jan	29	Interest	1.00		72.00		28.00	1%
1900	Jan	30	Interest	1.00		71.00		29.00	1%
1900	Jan	31	Interest	1.00		70.00		30.00	1%

No.	Time. mins.	R.P.M.	Press.	Load.	Temperature.		B.H.P.	Total air used.	Air per. B.H.P. hr. Lbs. Cu.Ft.	
					Before.	Exhaust.				

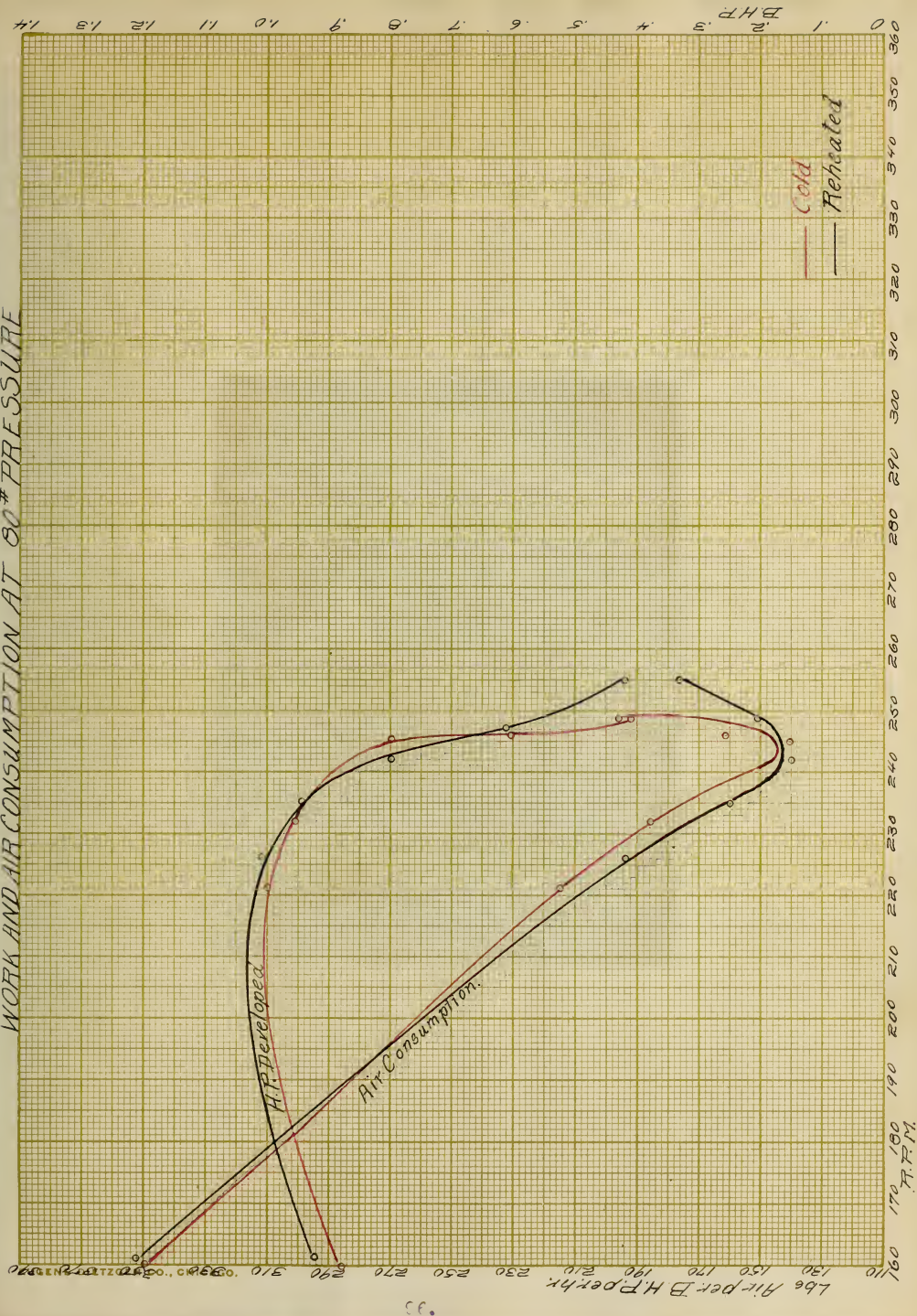
25.	15	226	80	12	175	79	1.12	54.06	182.8	2429
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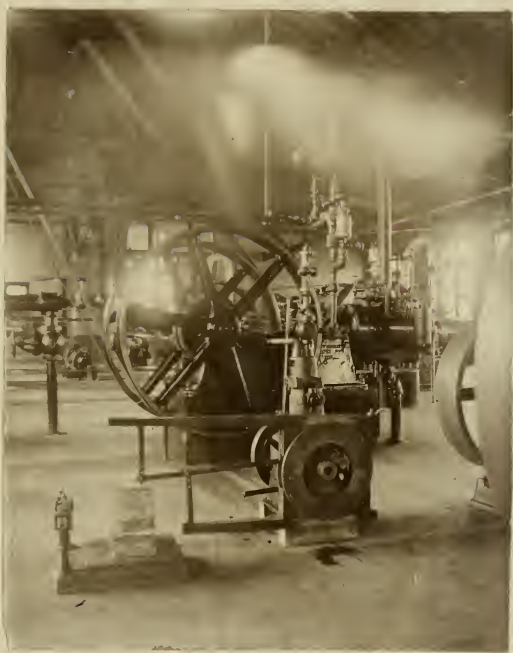
26.	15	161	80	14	158	90	.92	81.95	352.8	4435
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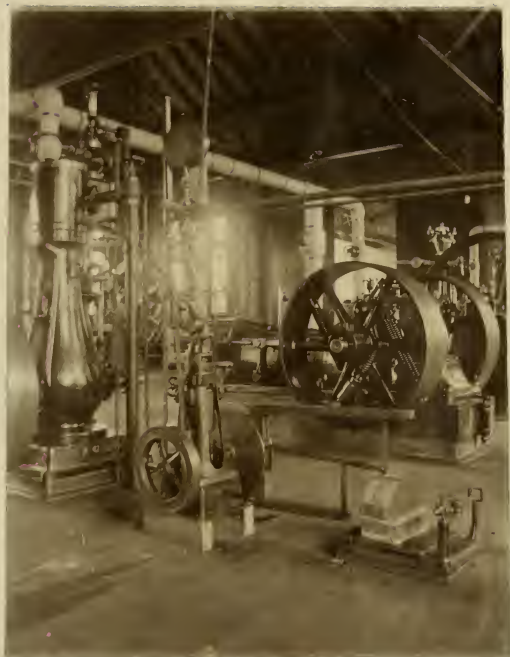
WORK AND AIR CONSUMPTION AT 65# PRESSURE

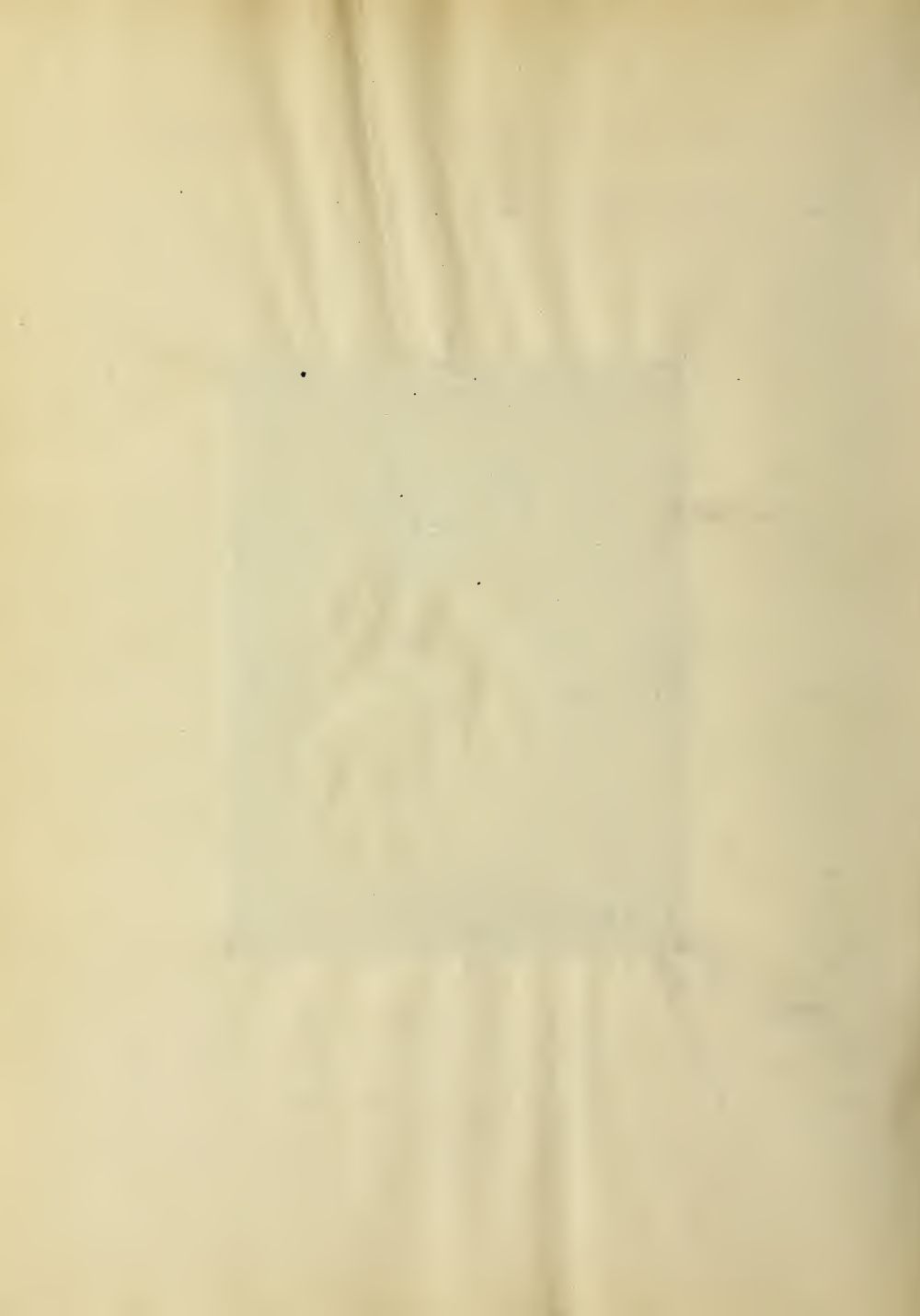


WORK AND AIR CONSUMPTION AT 80# PRESSURE









Comparison of Actual and Theoretical Gain in Heating Air.

Let I = Indicated Horse Power using air cold.

$I' =$ " " " " " heated.

$B =$ Brake " " " " cold..

$B' =$ " " " " " heated.

$T =$ Temperature of air cold.

$T' =$ " " " heated.

$v =$ Volume of air cold.

$v' =$ " " same weight of air heated.

$I = pv \times \text{some constant.}$

$I' = pv' \times$ " "

But with constant pressure $v : v' = T : T'$, therefore

$I : I' = T : T'$, with constant weight of air.

$I' = I \times T' / T.$

$B = I - F.$

$B' = I' - F = I \times T' / T - F.$

$B' - B = I (T' / T - 1) = I \frac{(T' - T)}{T}$

Gain and B.H.P. $= \frac{B' - B}{B} = \frac{I}{B} \frac{(T' - T)}{T}.$

Gain in I.H.P. $= \frac{T' - T}{T}.$

Evidently from the equations the gain in B.H.P. is greater than the gain in I.H.P. in the ratio $I : B$; hence experiments in which B.H.P. only were used should show a greater gain per. cent from re-heating than is given by the equations. This is the case in the experiments tried. The temperatures were 82 and 200 degrees F. so that $T = 543$, $T' = 661$. Therefore the gain in I.H.P. $= .2175$.

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From actual case the gain in B.H.P. = .244.

If we assume the efficiency of the engine to be .80 then $I / B = 1 / .80 = 1.25$; hence $\frac{I}{B} \times \frac{(T' - T)}{T} = 1.25 \times .2173 = .2717$ which should be the gain in B.H.P.

